

**Don't wait for the
opportunity. Create it.**

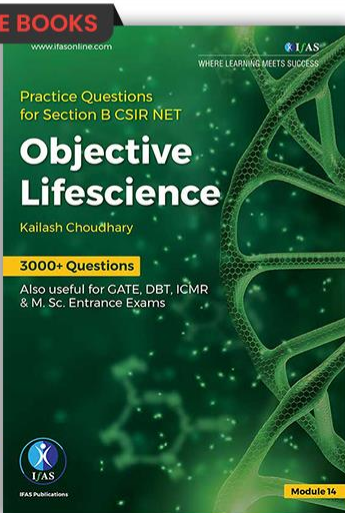
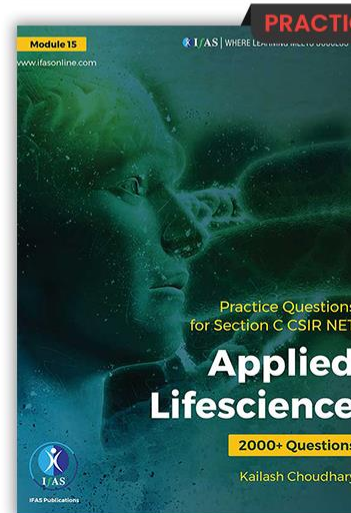
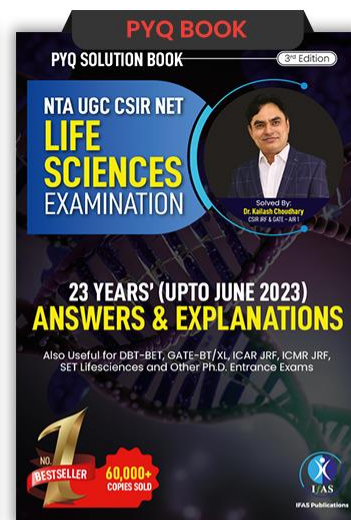
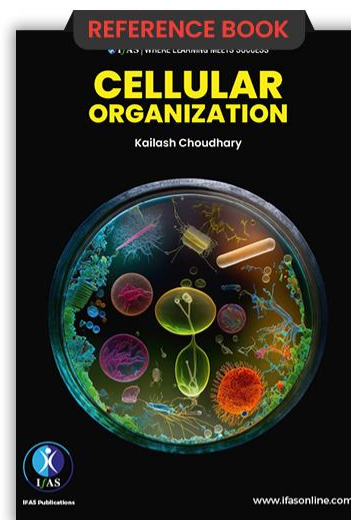
CSIR NET – Life Science

Unit 2: Cellular Organization

L16 Mitosis and meiosis



Order Online and Get
Free Delivery Across India





Points to be covered in this Lecture



Mitosis and meiosis



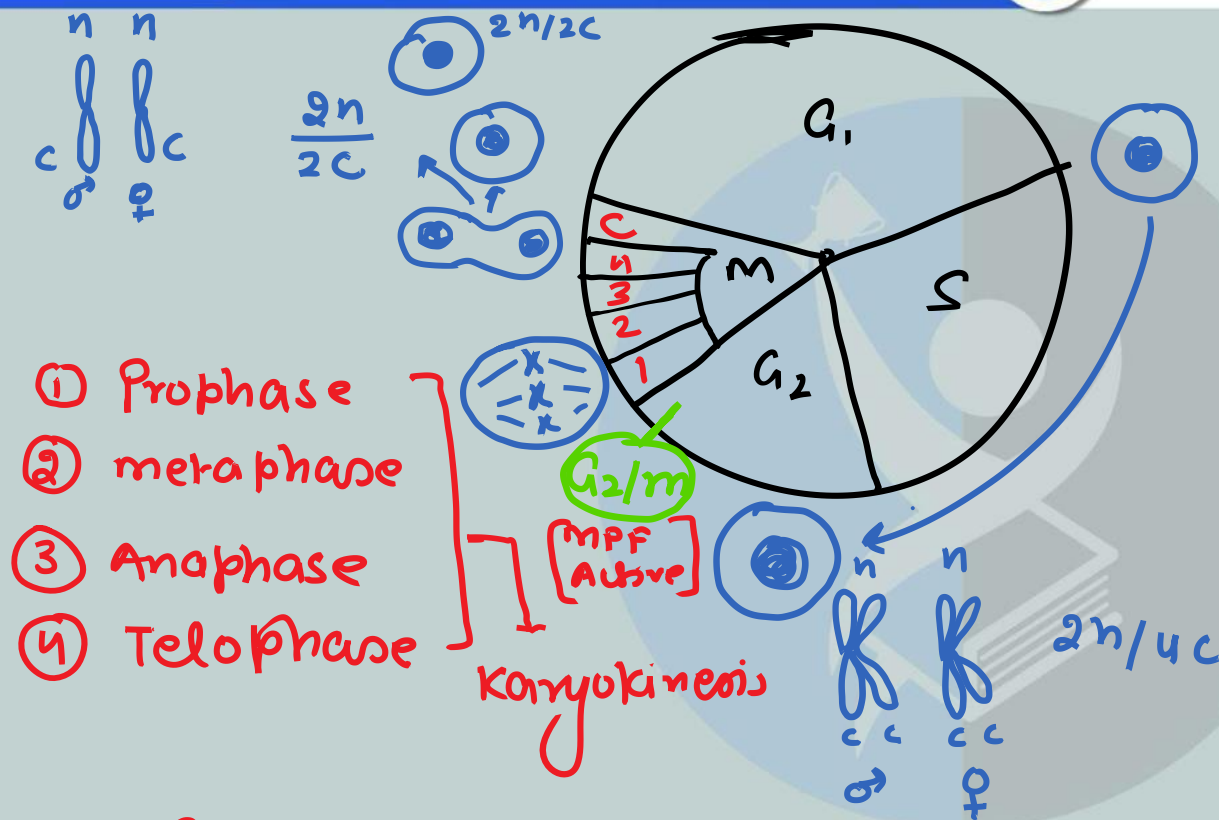
Stages of mitosis, Spindle Assembly
check point



Cytokinesis, Cell fusion of different
stages



Stages of meiosis



C = Cytokinesis

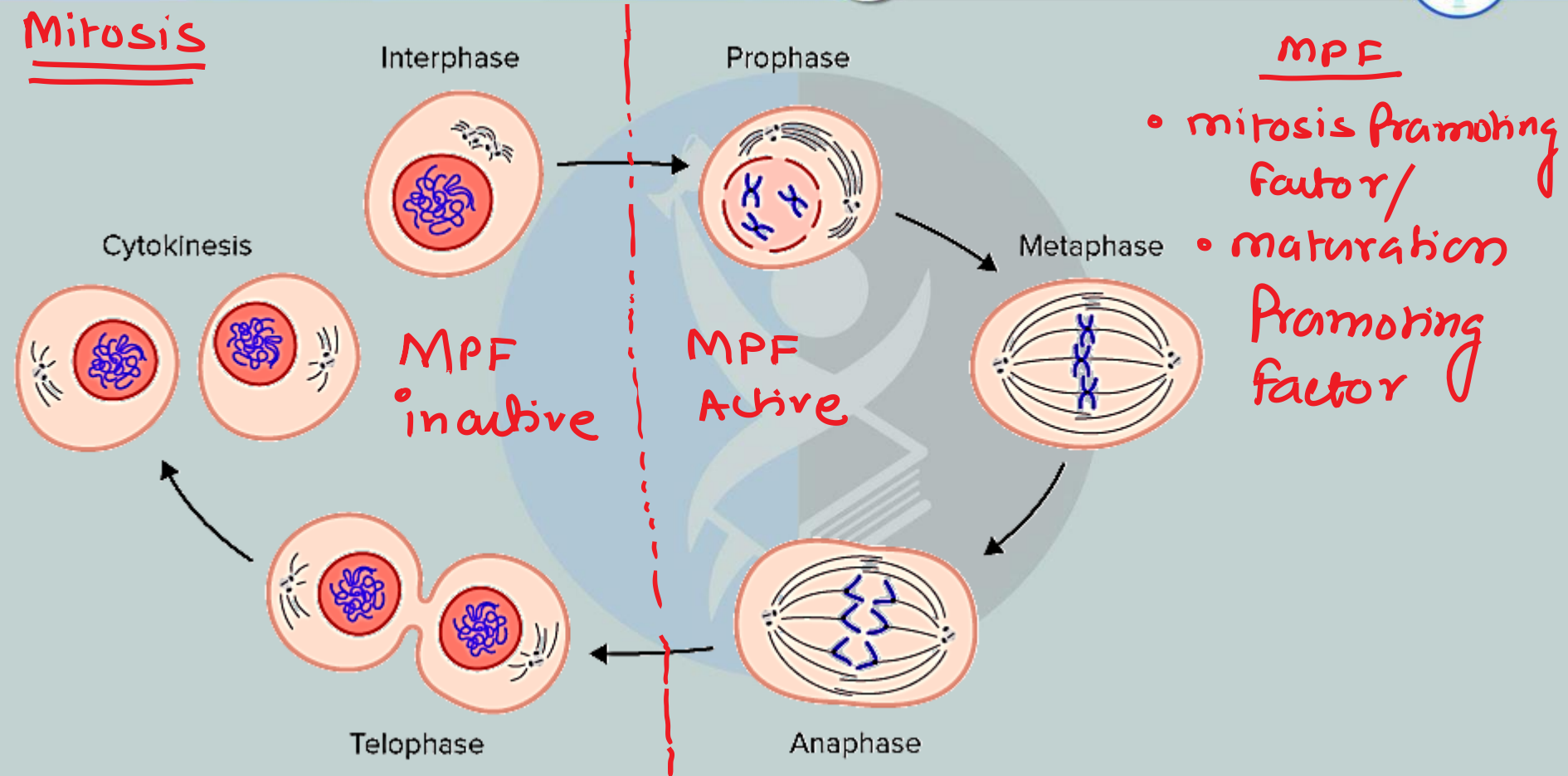
mitosis

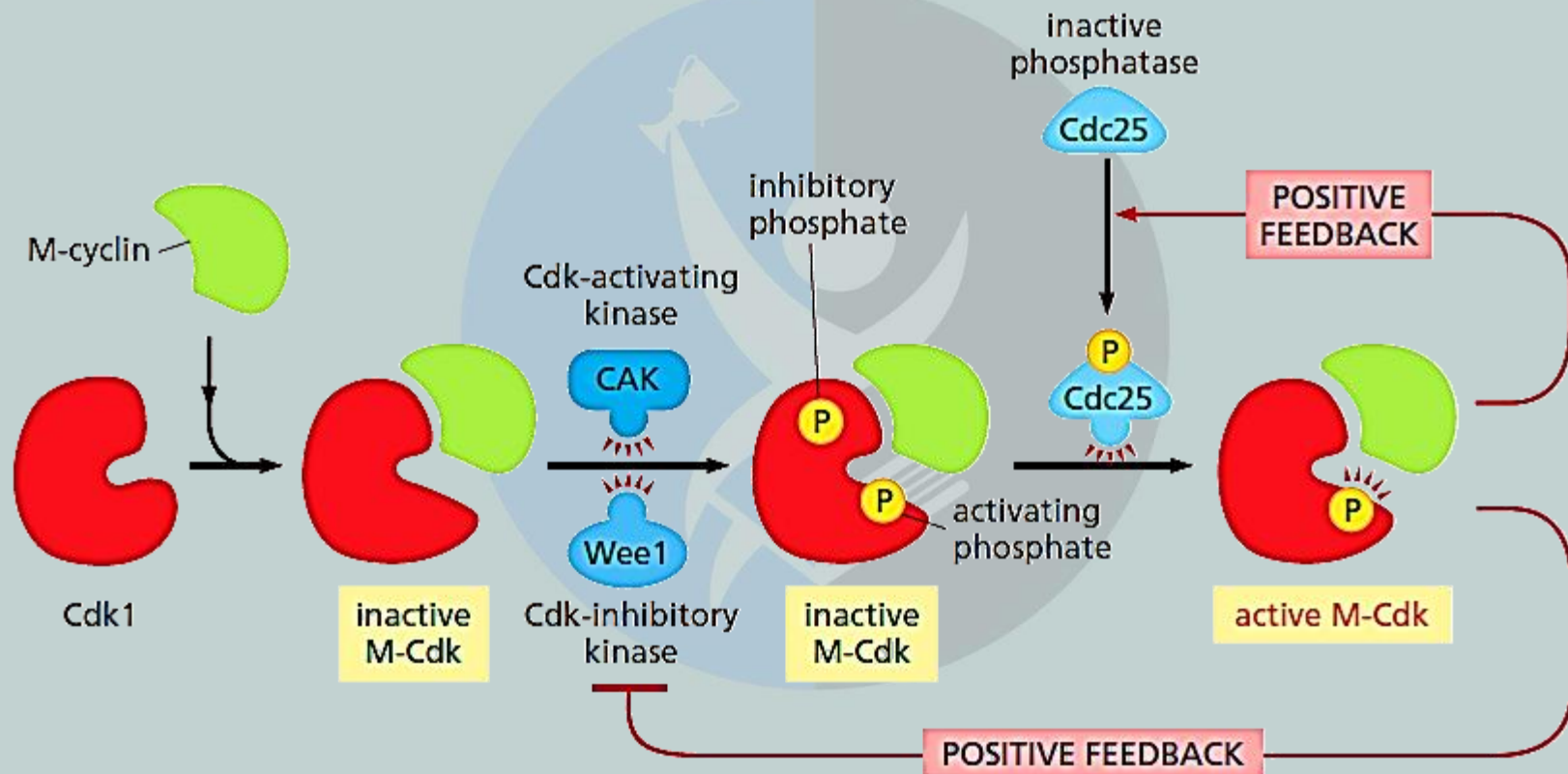
- Cell Division
- Growth in cell No.
- Embryonic development



Growth

Mitosis





M phase CDK1 + Cyclin B, Cdc25, Phosphatase, CAK Active MPF, Mitosis promoting factor

M phase start, Mitosis,

(1) Karyokinesis,

(2) Cytokinesis

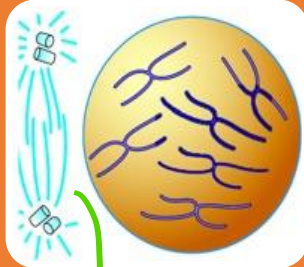
Remove
P from MPF

add
Activator
P

- ✓ (1) Prophase,
- ✓ (2) Metaphase,
- ✓ (3) Anaphase,
- ✓ (4) Telophase



Prophase

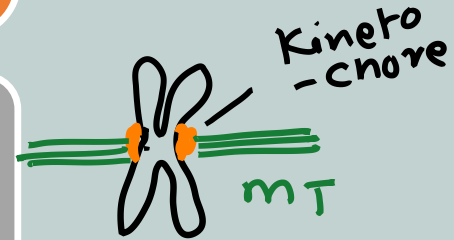


mitotic spindle

- MPF active, chromosomal material condenses to form compact mitotic chromosomes.
- Chromosomes are seen to be composed of two chromatids attached together at the centromere.
- Cytoskeleton is disassembled and mitotic spindle is assembled.
- Golgi complex and ER fragment. Nuclear envelope disperses.



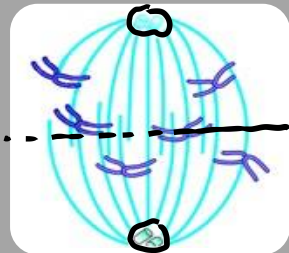
centromere



Kinetochores

MT

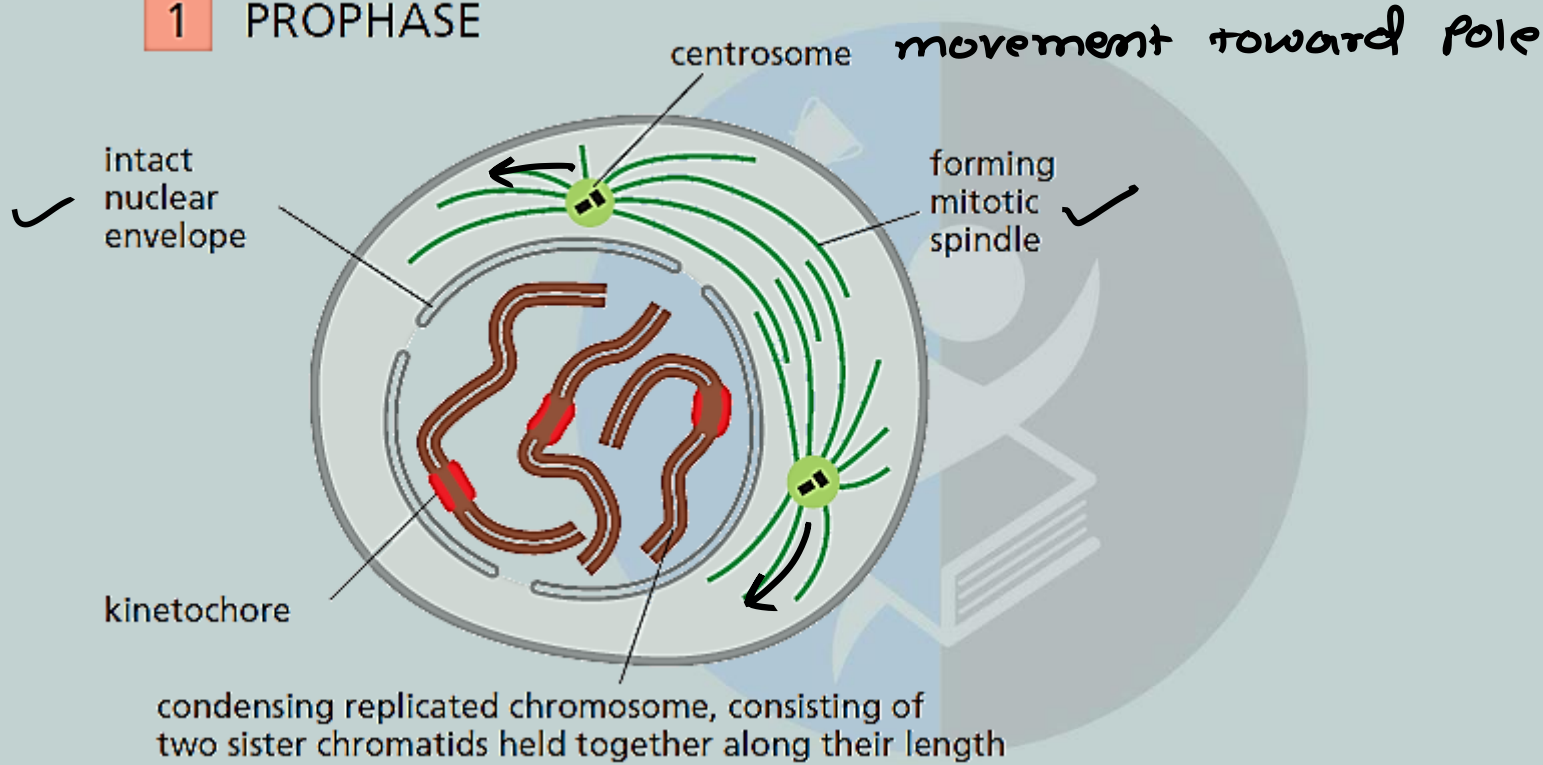
Prometaphase / Late Prophase



- Chromosomal microtubules attach to kinetochores of chromosomes.
- Chromosomes are moved to spindle equator.

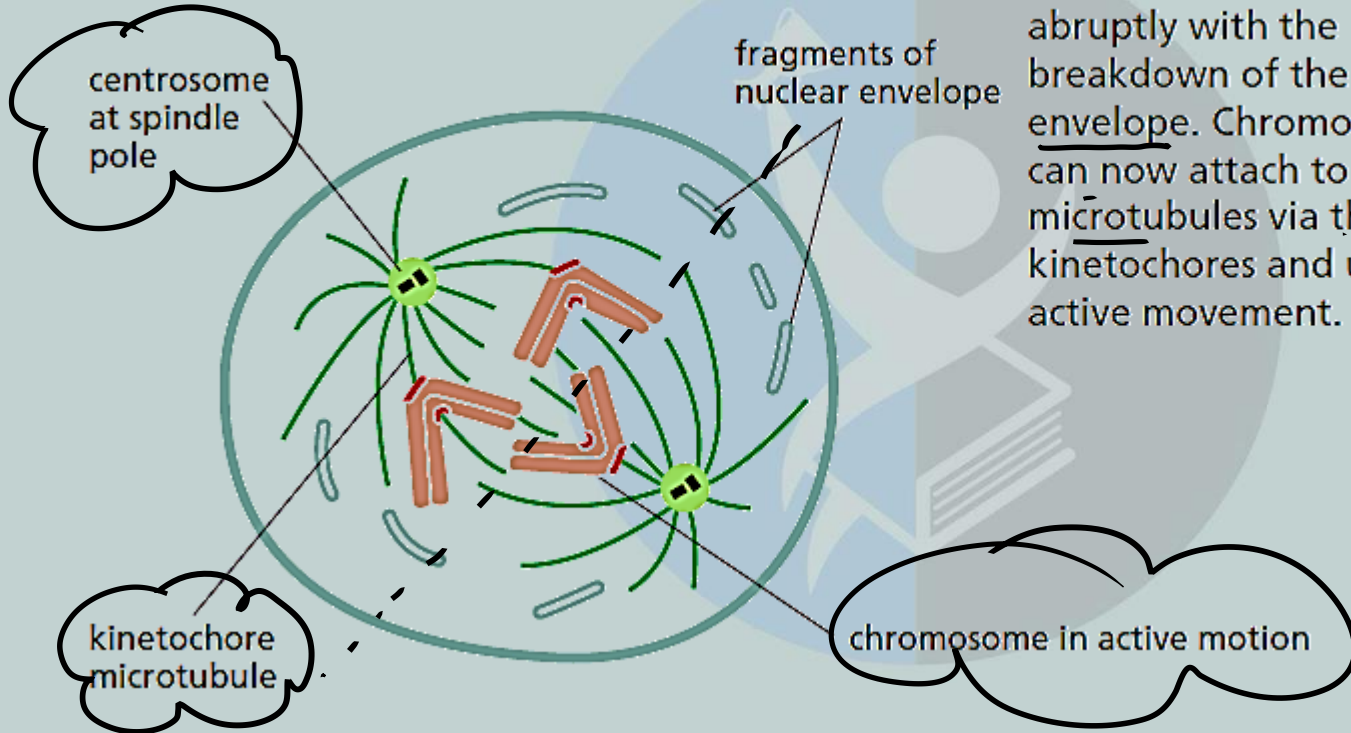


1 PROPHASE



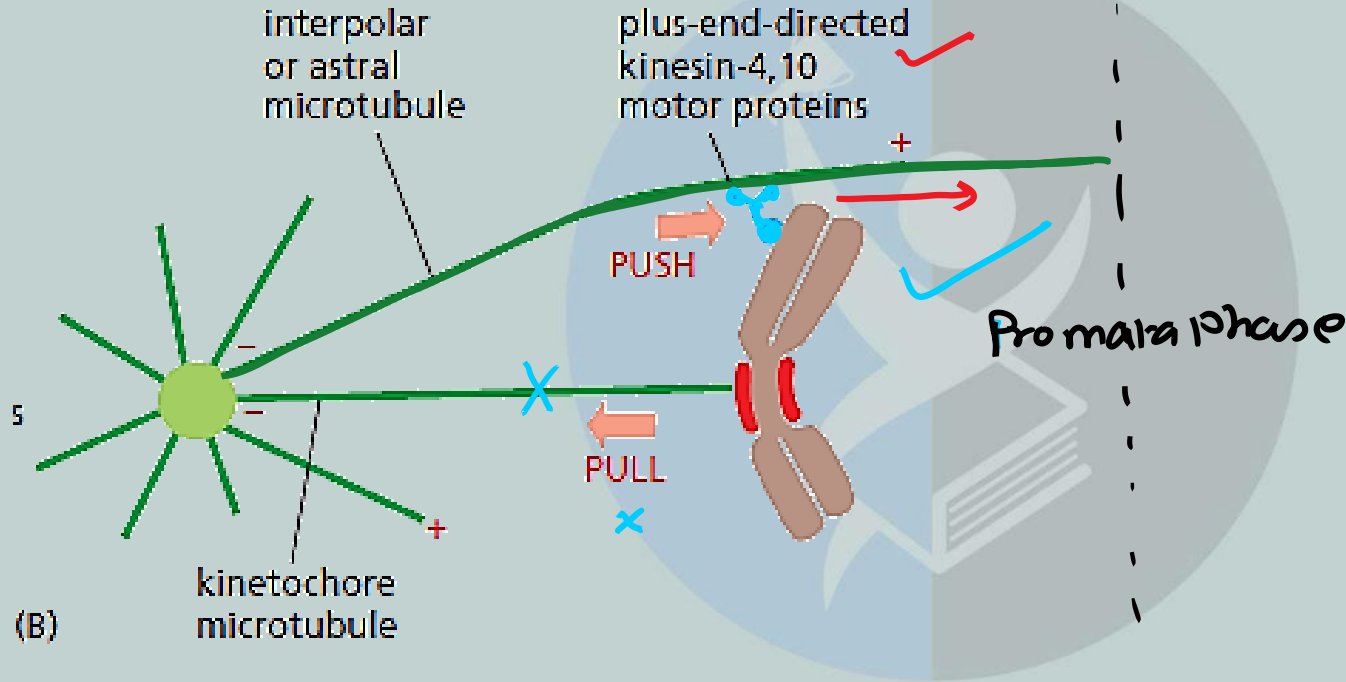


2 PROMETAPHASE



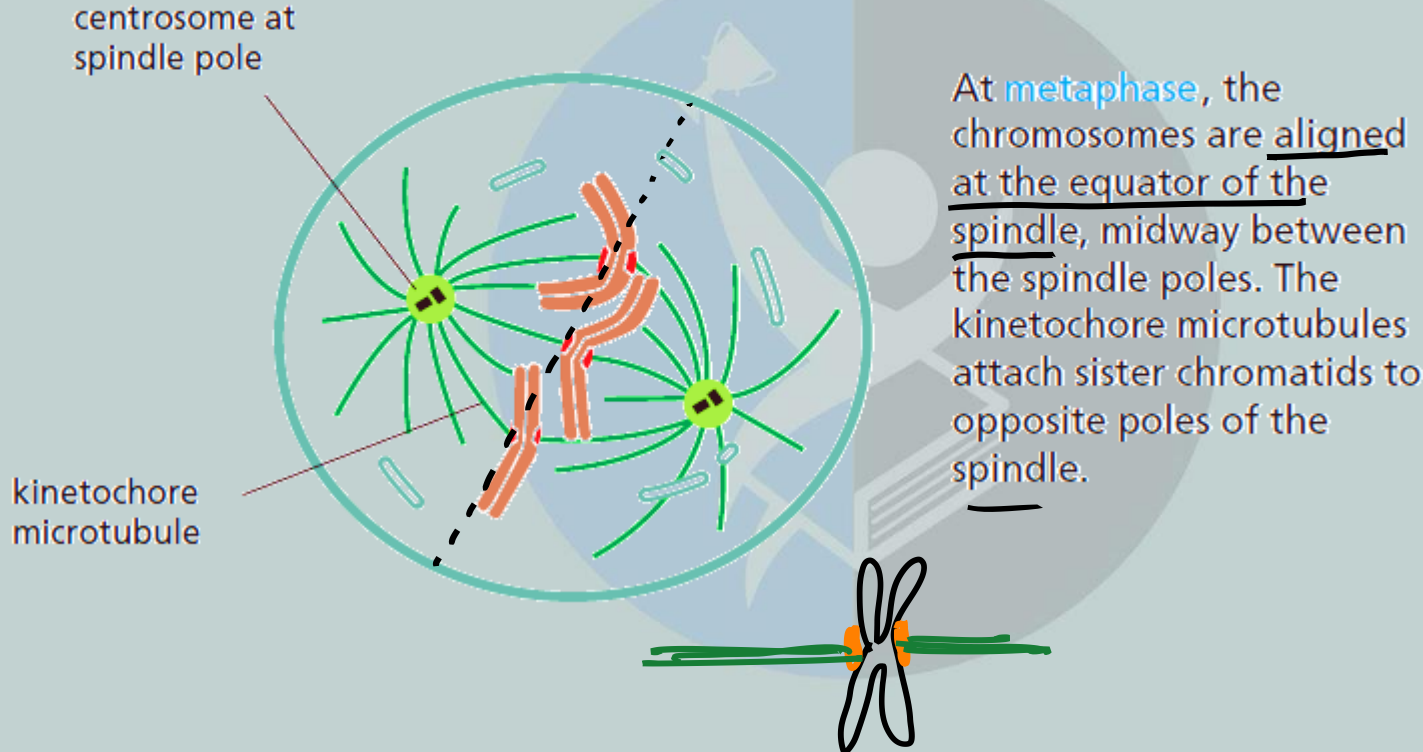
MPF Active - Add (p) on
- Nuclear lamin

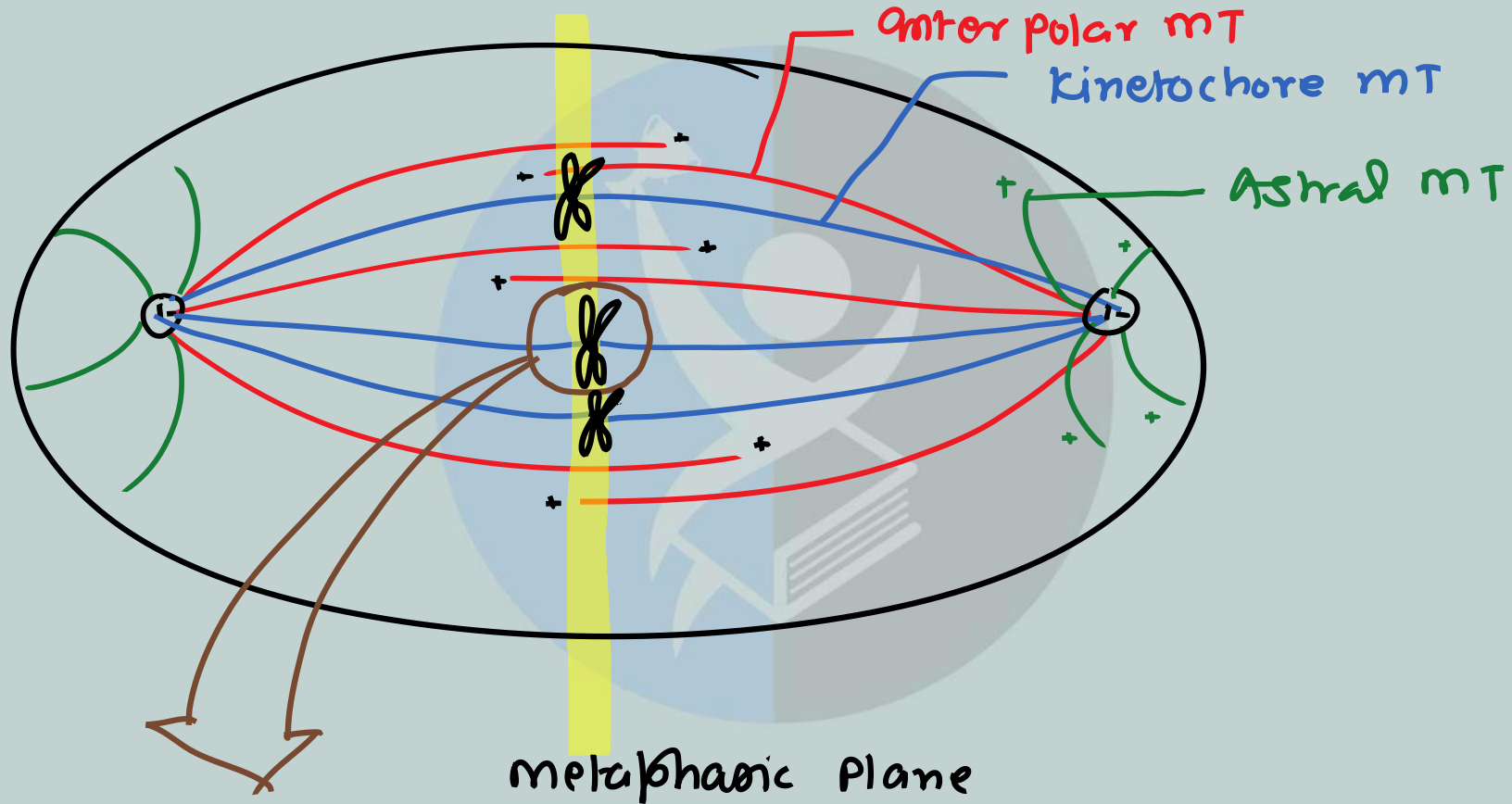
- ✓ Prometaphase starts abruptly with the breakdown of the nuclear envelope. Chromosomes can now attach to spindle microtubules via their kinetochores and undergo active movement.

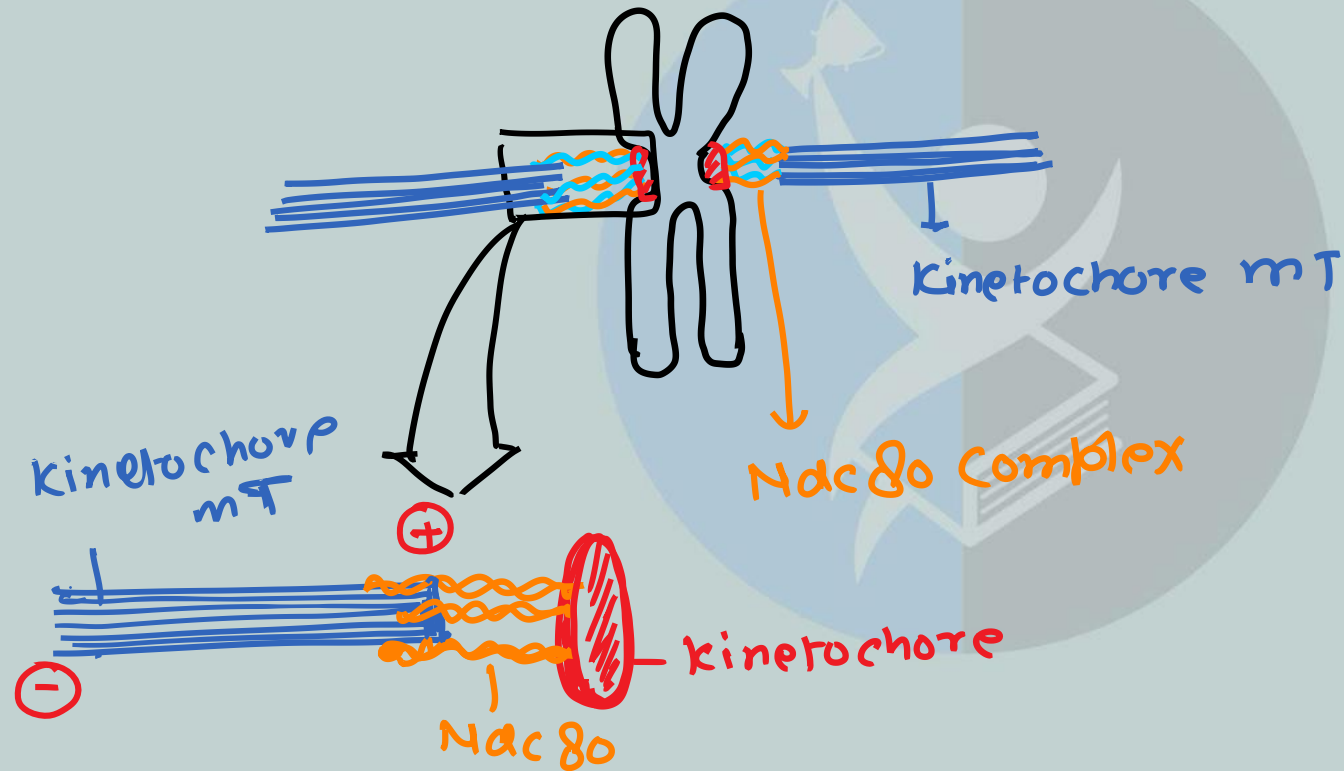




3 METAPHASE

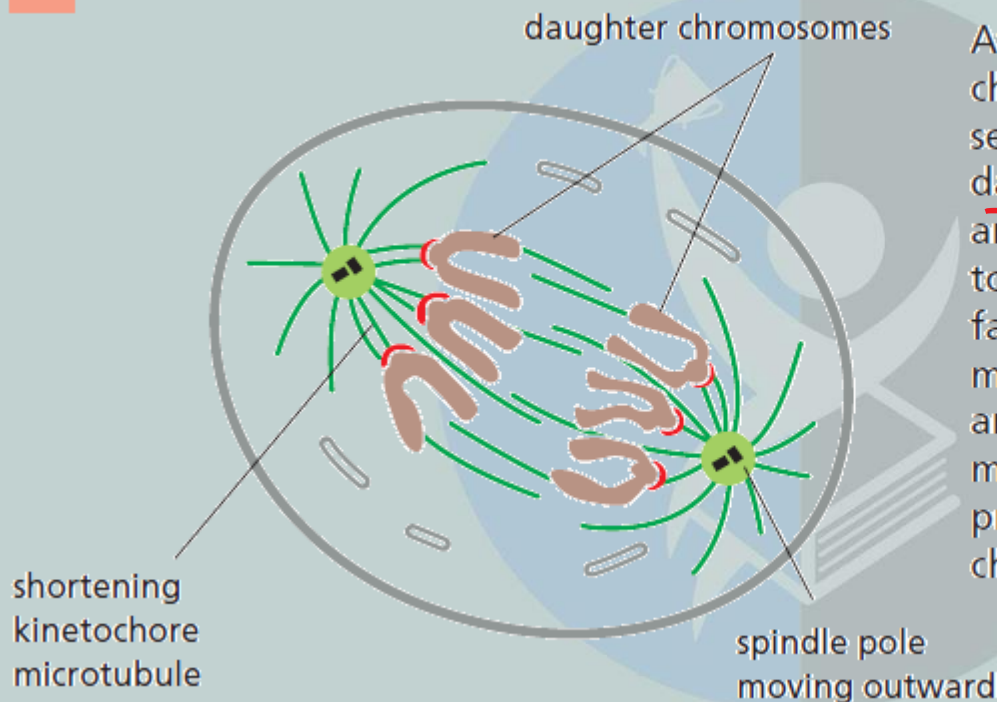








4 ANAPHASE



At **anaphase**, the sister chromatids synchronously separate to form two daughter chromosomes, and each is pulled slowly toward the spindle pole it faces. The kinetochore microtubules get shorter, and the spindle poles also move apart; both processes contribute to chromosome segregation.



Anaphase



cohesin

degradation of cohesin by separase



- Kinetochore-microtubule depolymerize from +ve end

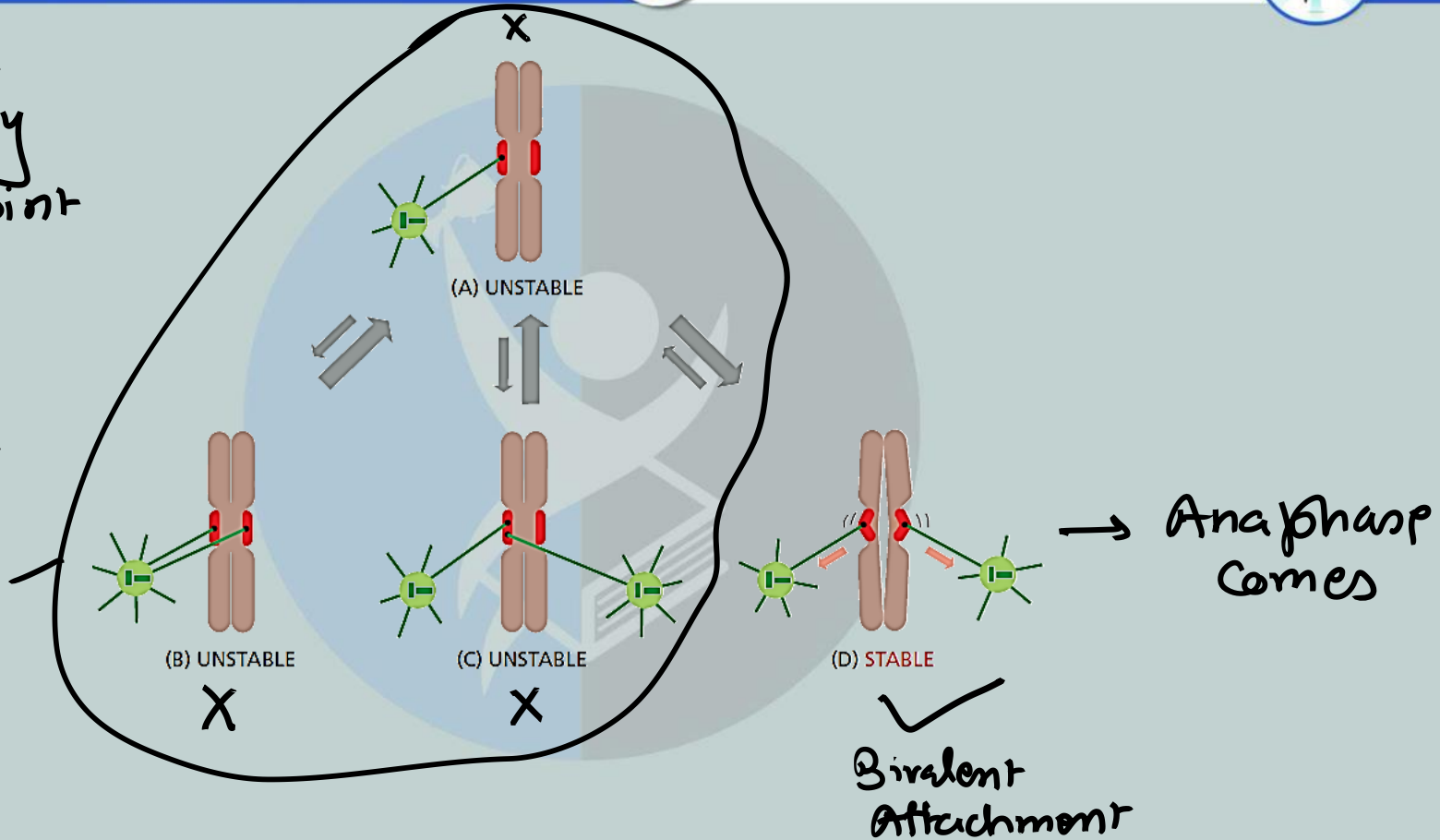


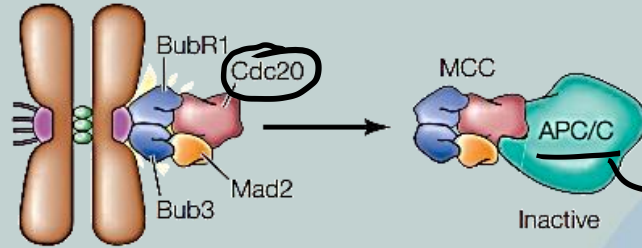
- Anaphase comes when spindle assembly on kinetochore of chromosome is correct



• Spindle Assembly Check Point

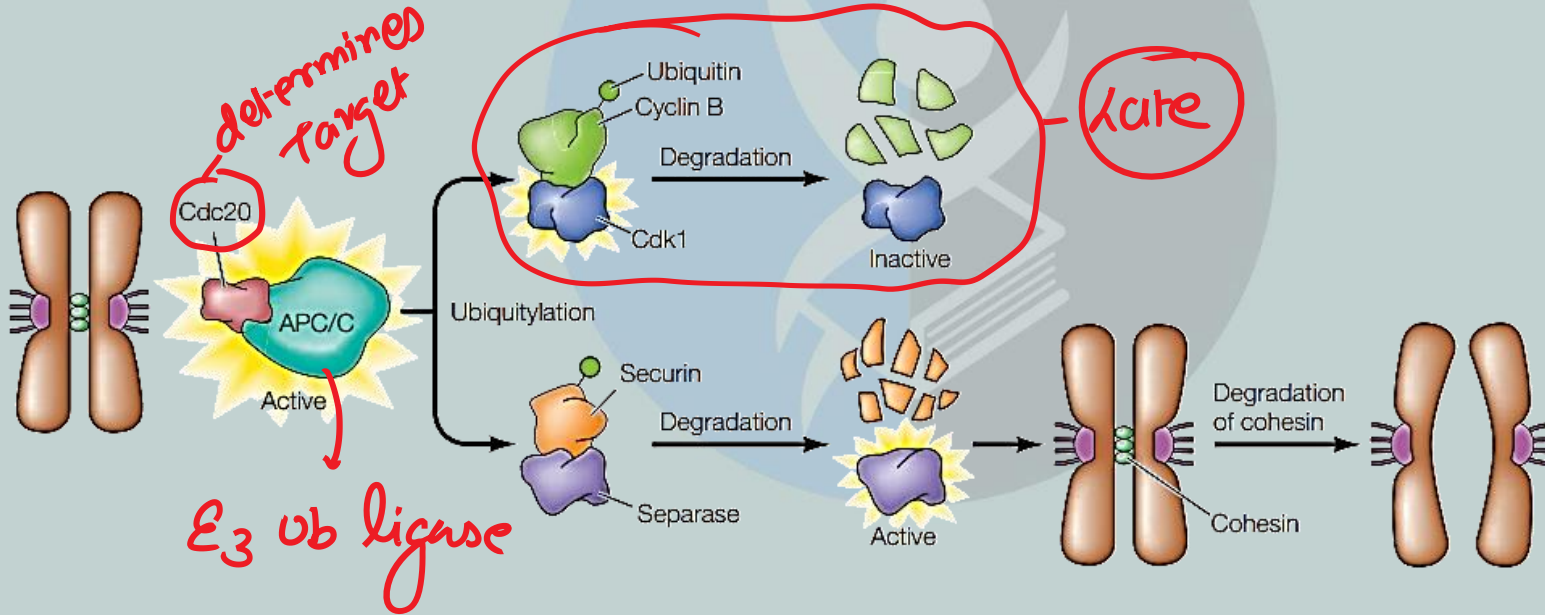
No Anaphase



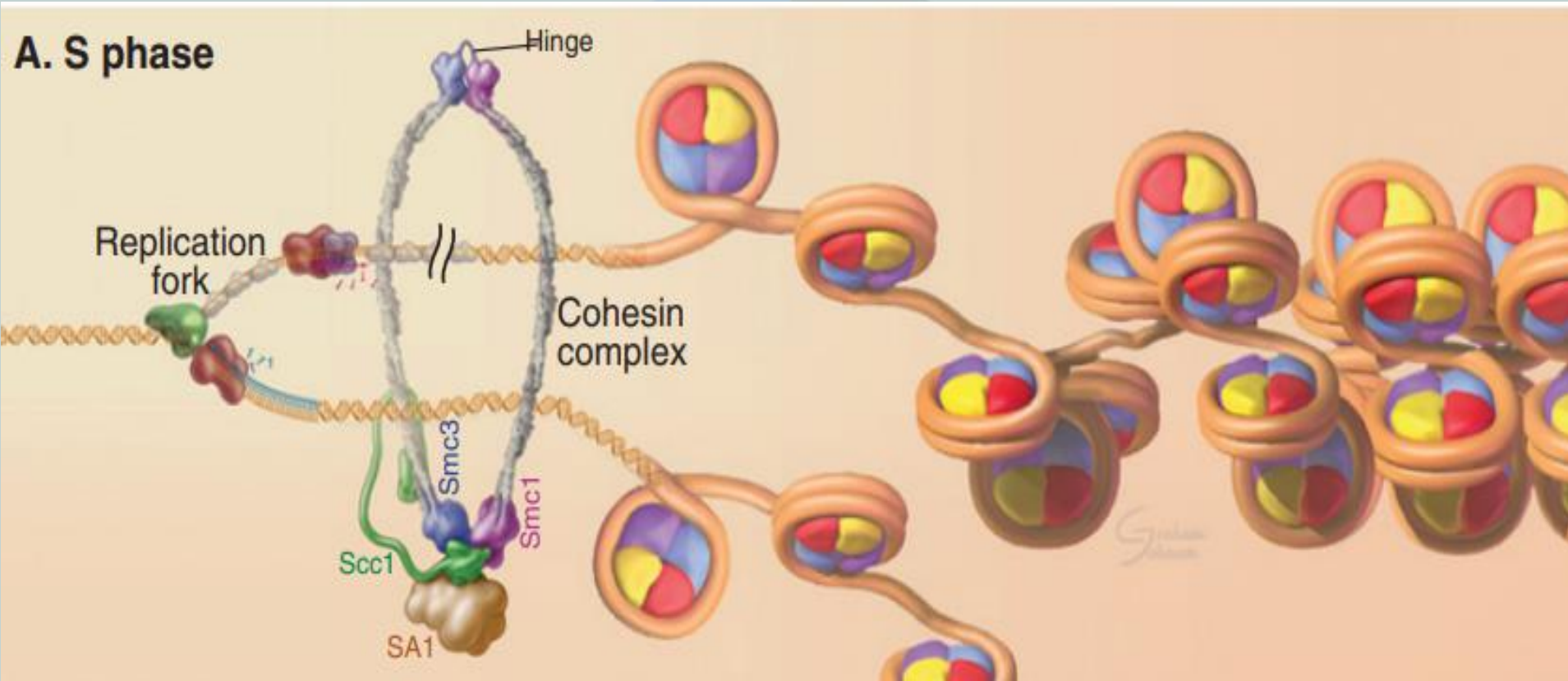


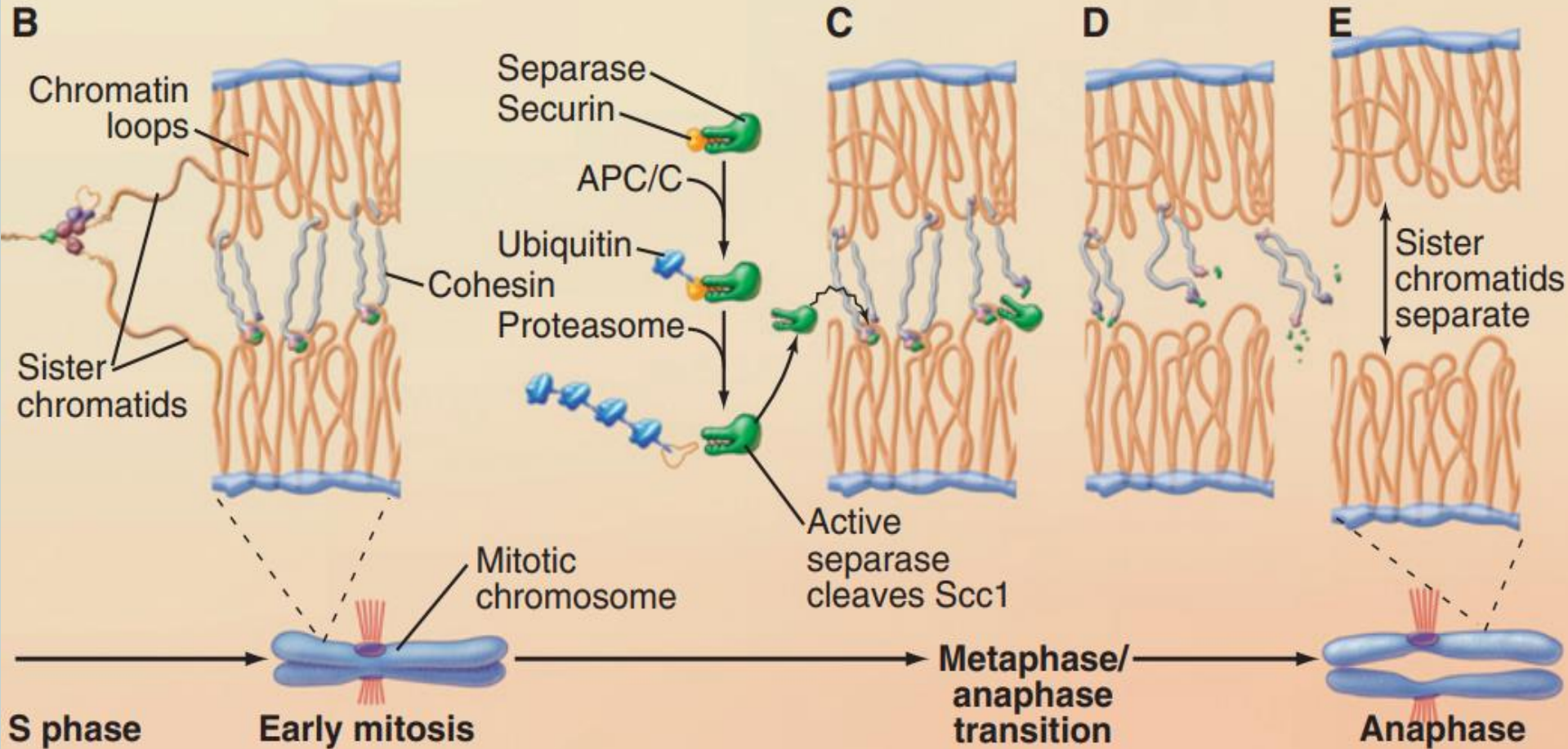
The spindle assembly checkpoint

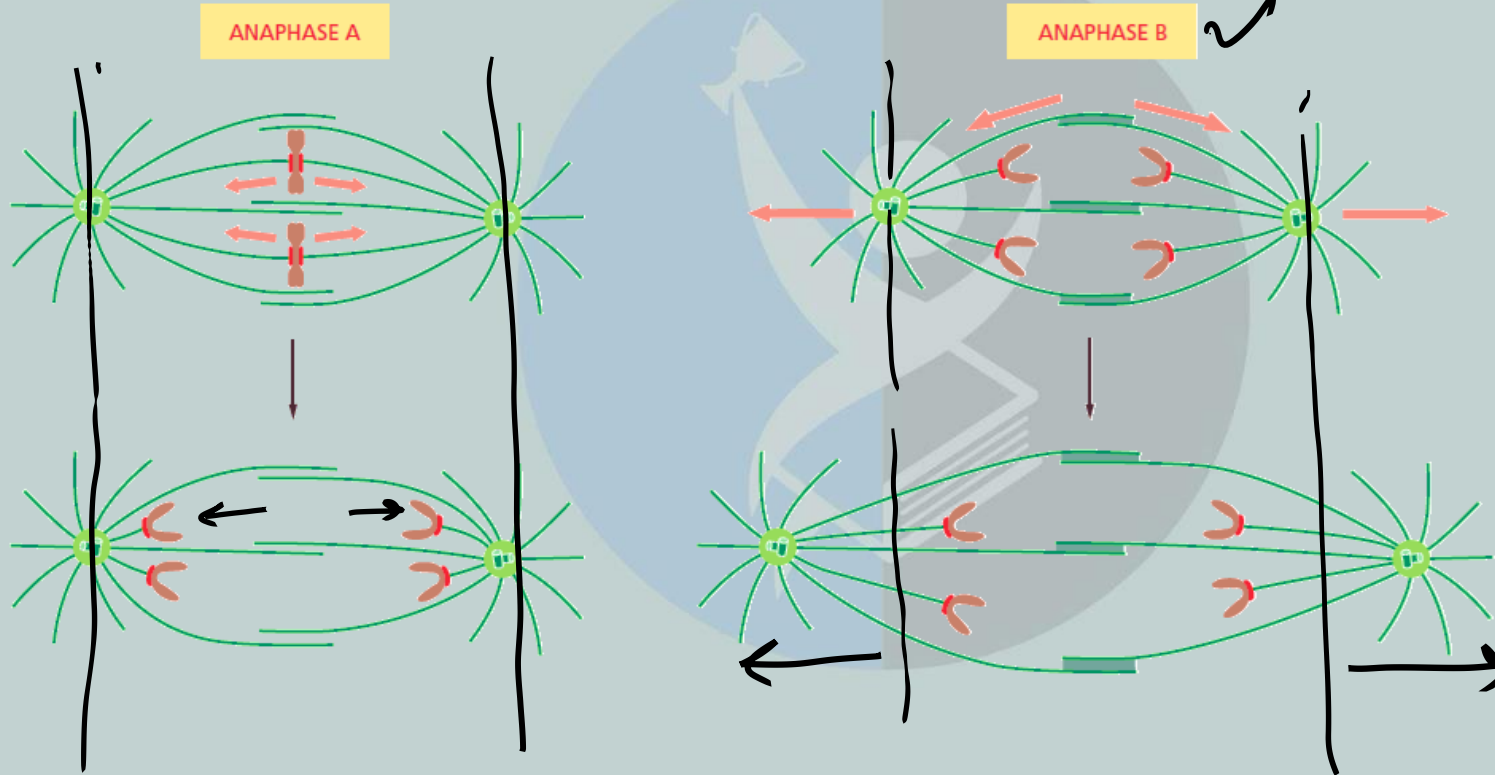
APC = Anaphase Promoting Complex



REGULATION OF SISTER CHROMATID PAIRING BY THE COHESIN COMPLEX







A. Anaphase

Cohesin
degrades

Sister chromatids separate

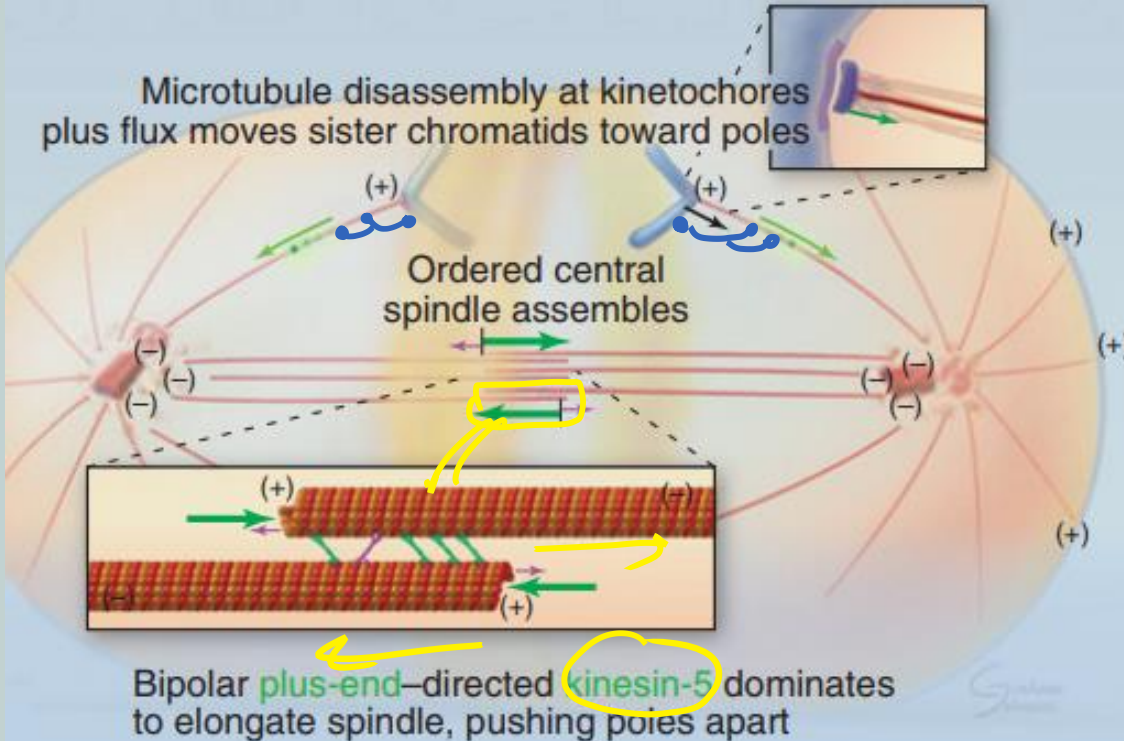
Anaphase A: Chromatids approach
poles (APC/C^{Cdc20} active)

Interdigitated interpolar
microtubules bundled by PRC1
and stem body material to
form central spindle

✓ **Anaphase B:** Spindle poles
migrate apart (APC/C^{Cdh1} active)

Spindles

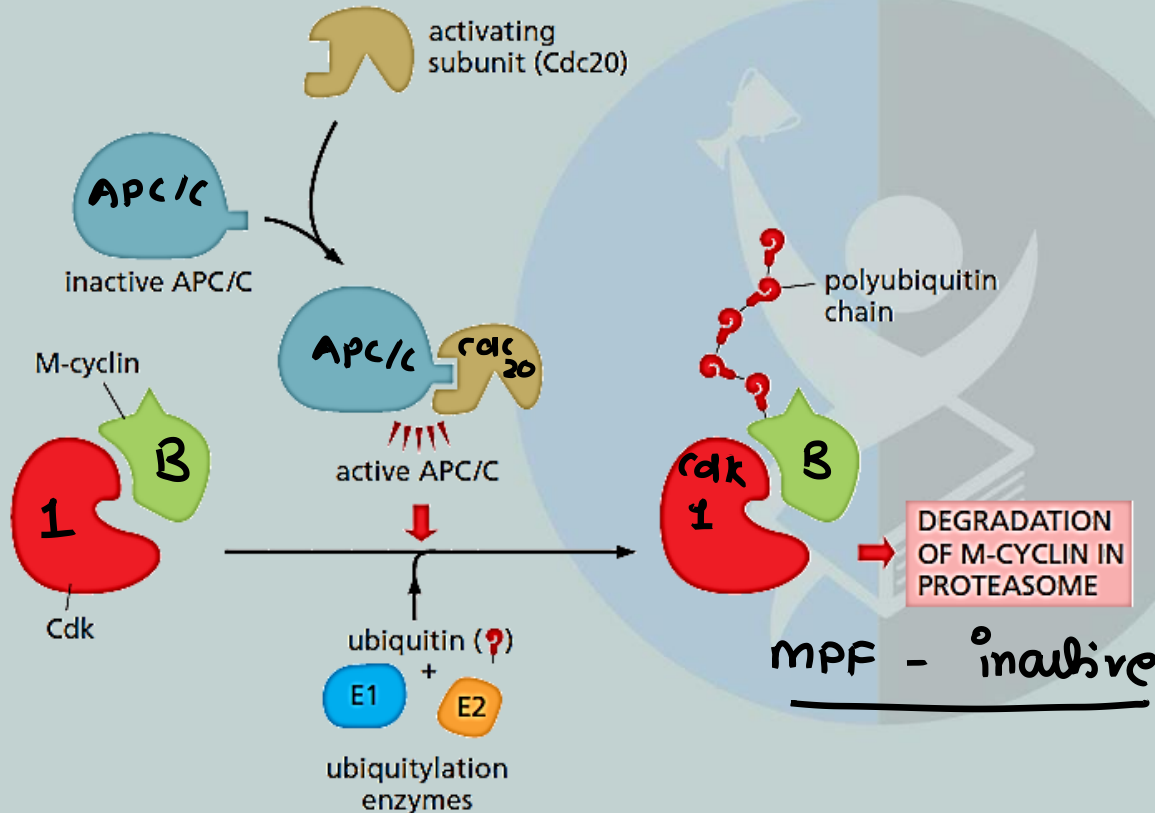
B. Anaphase—forces elongating the spindle dominate



3. Ubiquitin-Protein Ligases

✓ SCF ✓	Degradation of phosphorylated <u>Sic 1</u> or <u>p27</u> to activate S phase CDKs
✓ <u>APC/C^{Cdc20}</u>	Degradation of <u>securin</u> , initiating anaphase. Induces degradation of <u>B-type cyclins</u>
✓ <u>APC/C^{Cdh1}</u>	<u>Degradation of B-type cyclins</u> in G1 and geminin in metazoans to allow loading of replicative helicases on DNA replication origins.

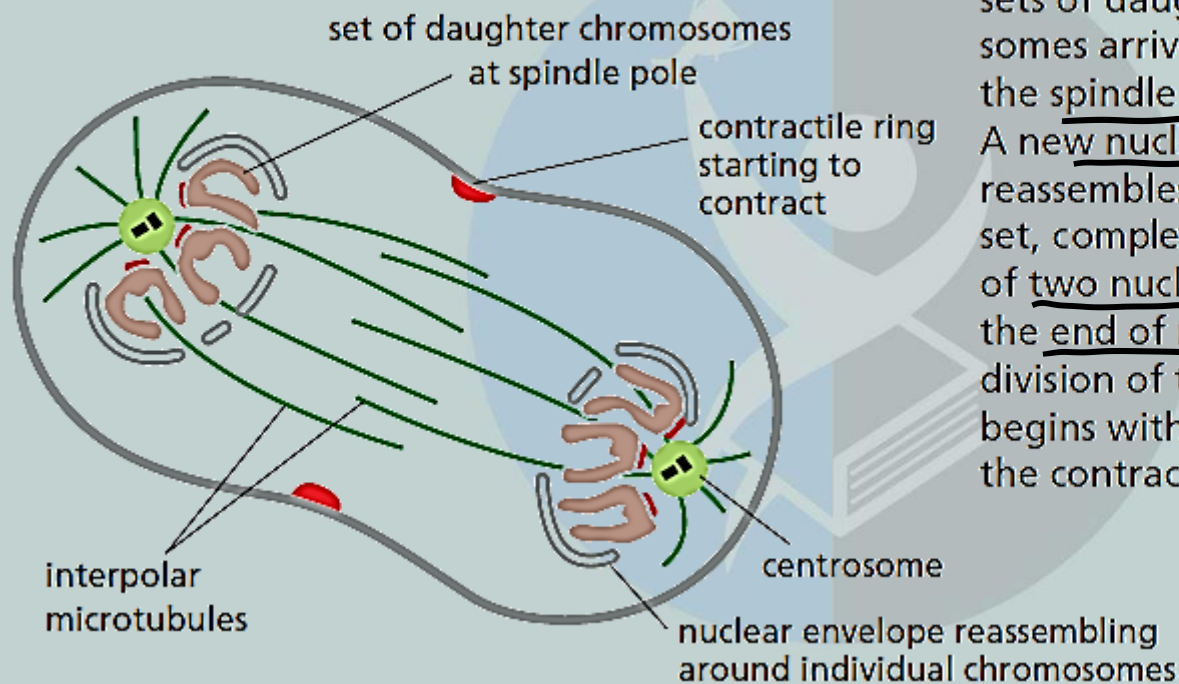
(A) control of proteolysis by APC/C



Phosphatase active
↓
Remove P from
MPF Target site



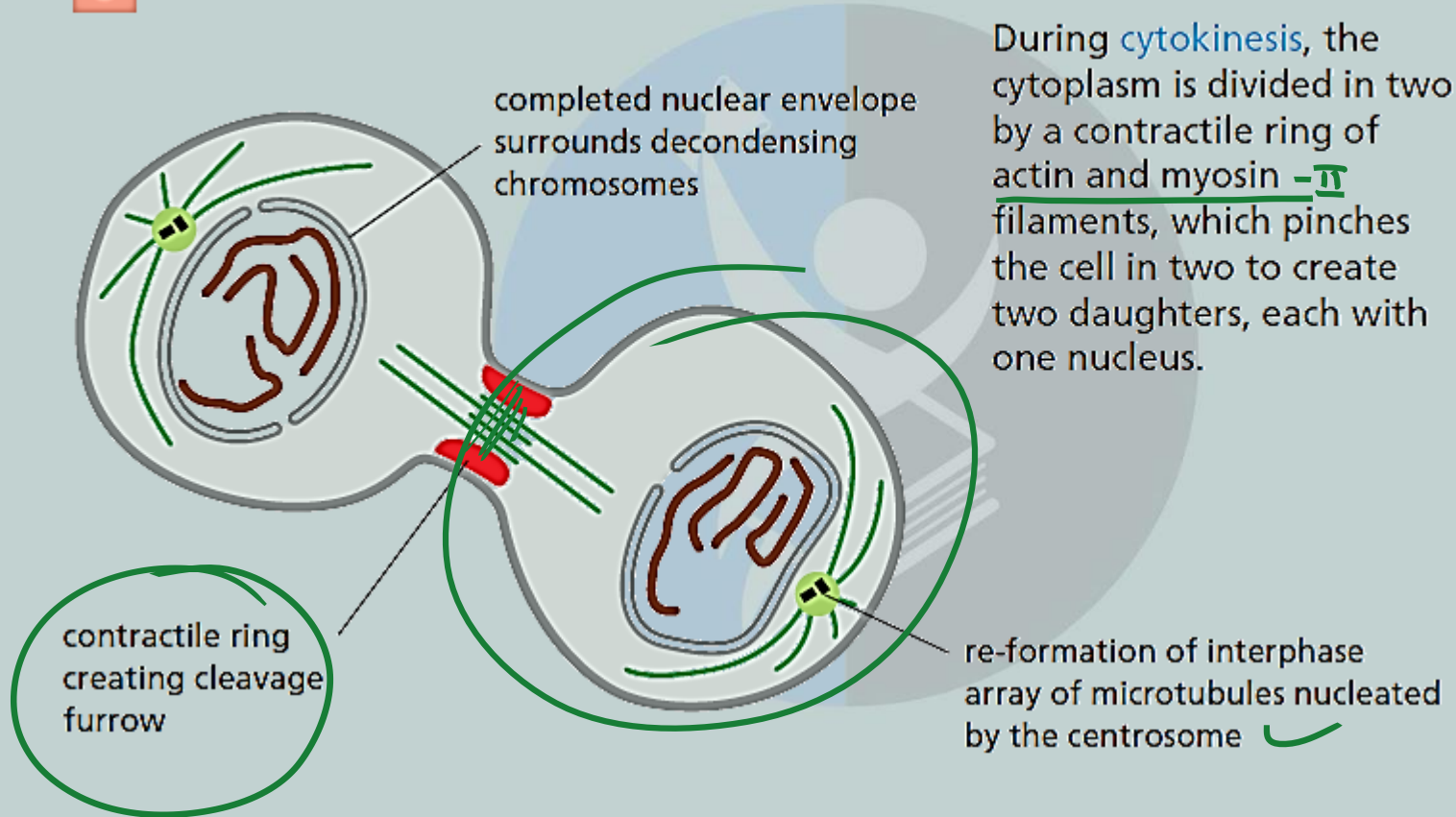
5 TELOPHASE



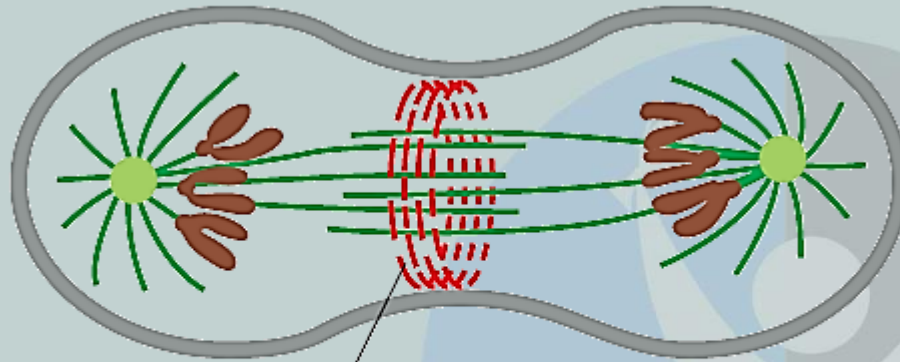
During **telophase**, the two sets of daughter chromosomes arrive at the poles of the spindle and decondense. A new nuclear envelope reassembles around each set, completing the formation of two nuclei and marking the end of mitosis. The division of the cytoplasm begins with contraction of the contractile ring.



6 CYTOKINESIS



During **cytokinesis**, the cytoplasm is divided in two by a contractile ring of actin and myosin -II filaments, which pinches the cell in two to create two daughters, each with one nucleus.



actin and myosin filaments of the
contractile ring

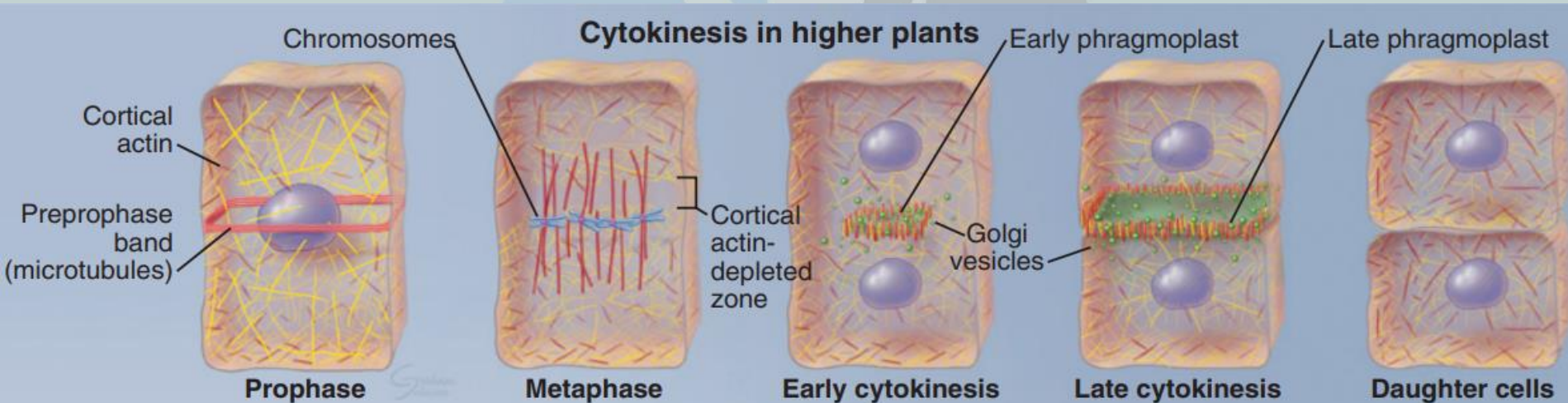
(A)

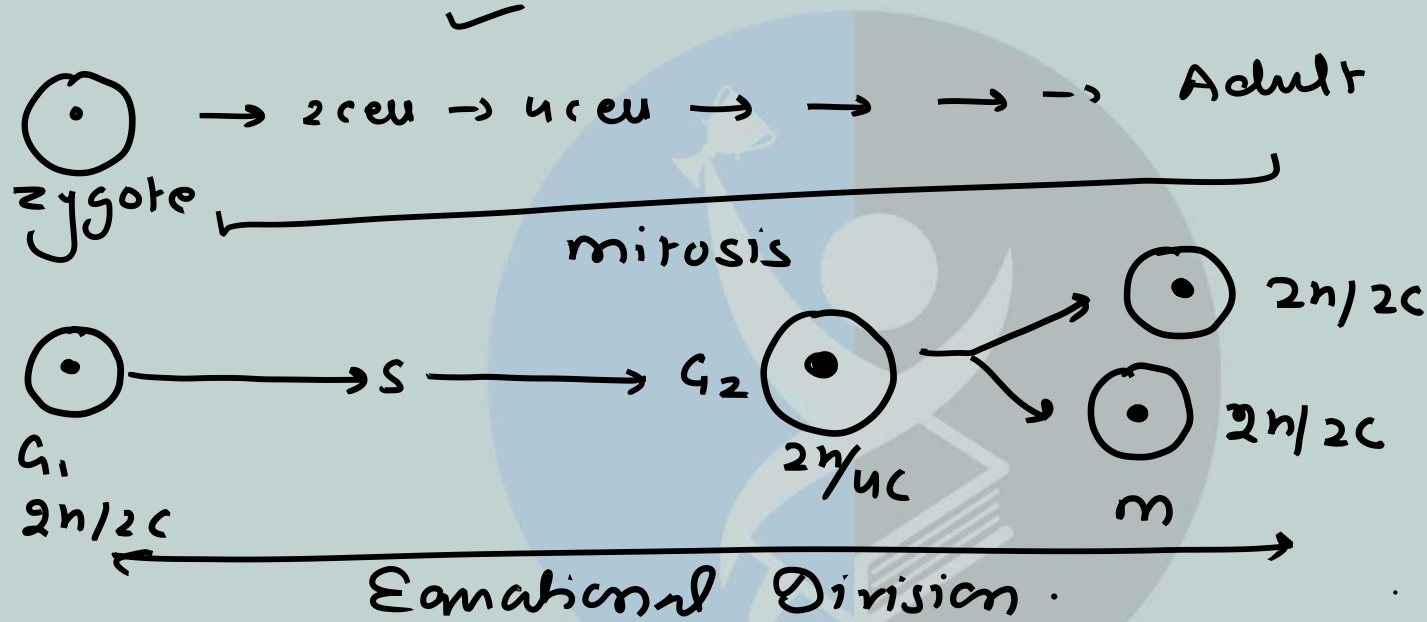
↓

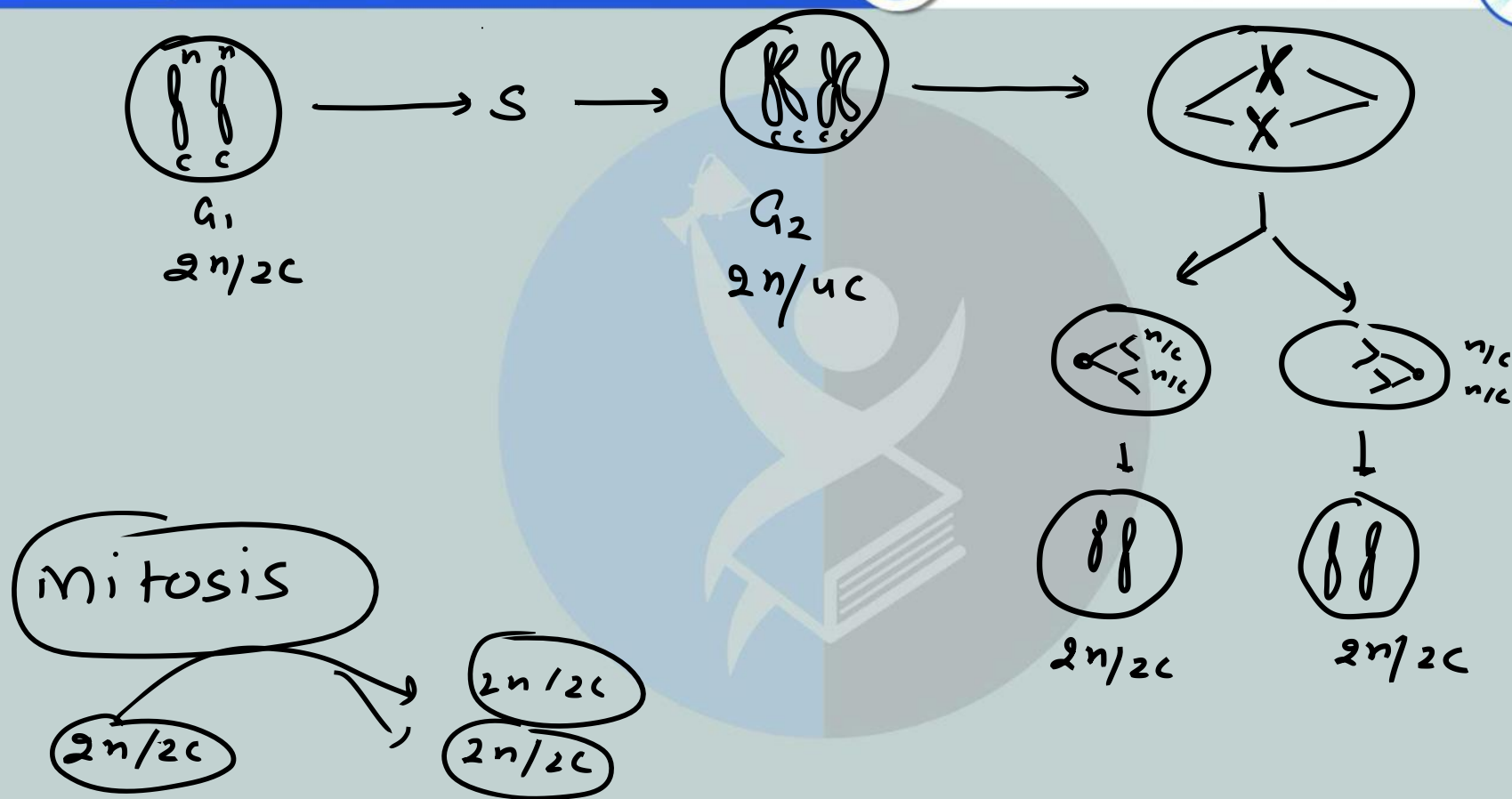
Cell division in plants

-> Actin, Myosin, Contractile ring does not form during cytokinesis

> Formation of **Phragmoplast** - cytokinesis





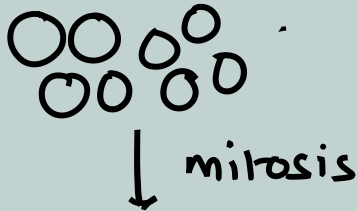




* Meiosis

- occurs in **gamete** (Form gamete n/c)
- Participate in **reproduction**, fertilization
- Meiosis maintain chromosomal balance in new generation

Adult

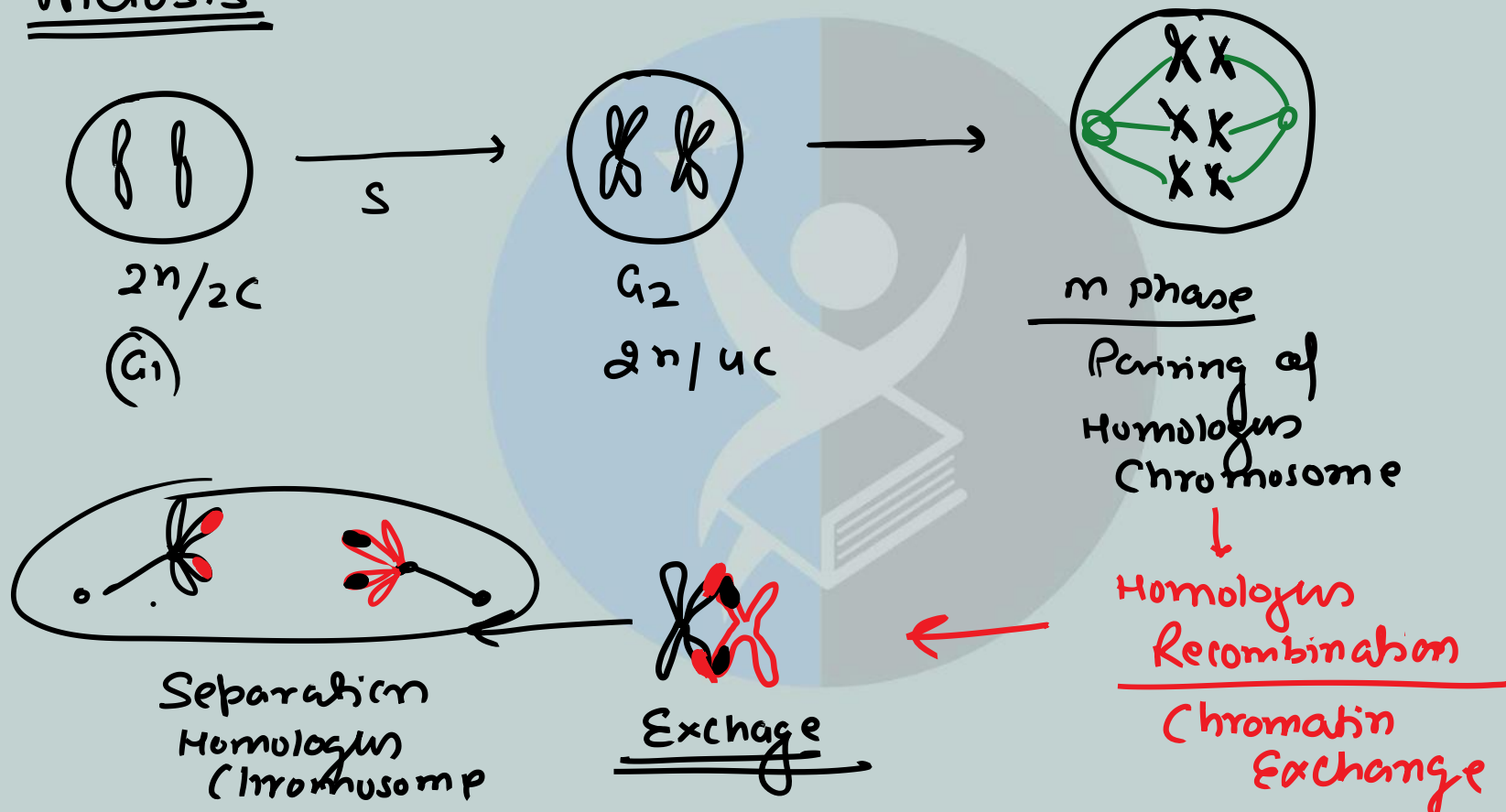


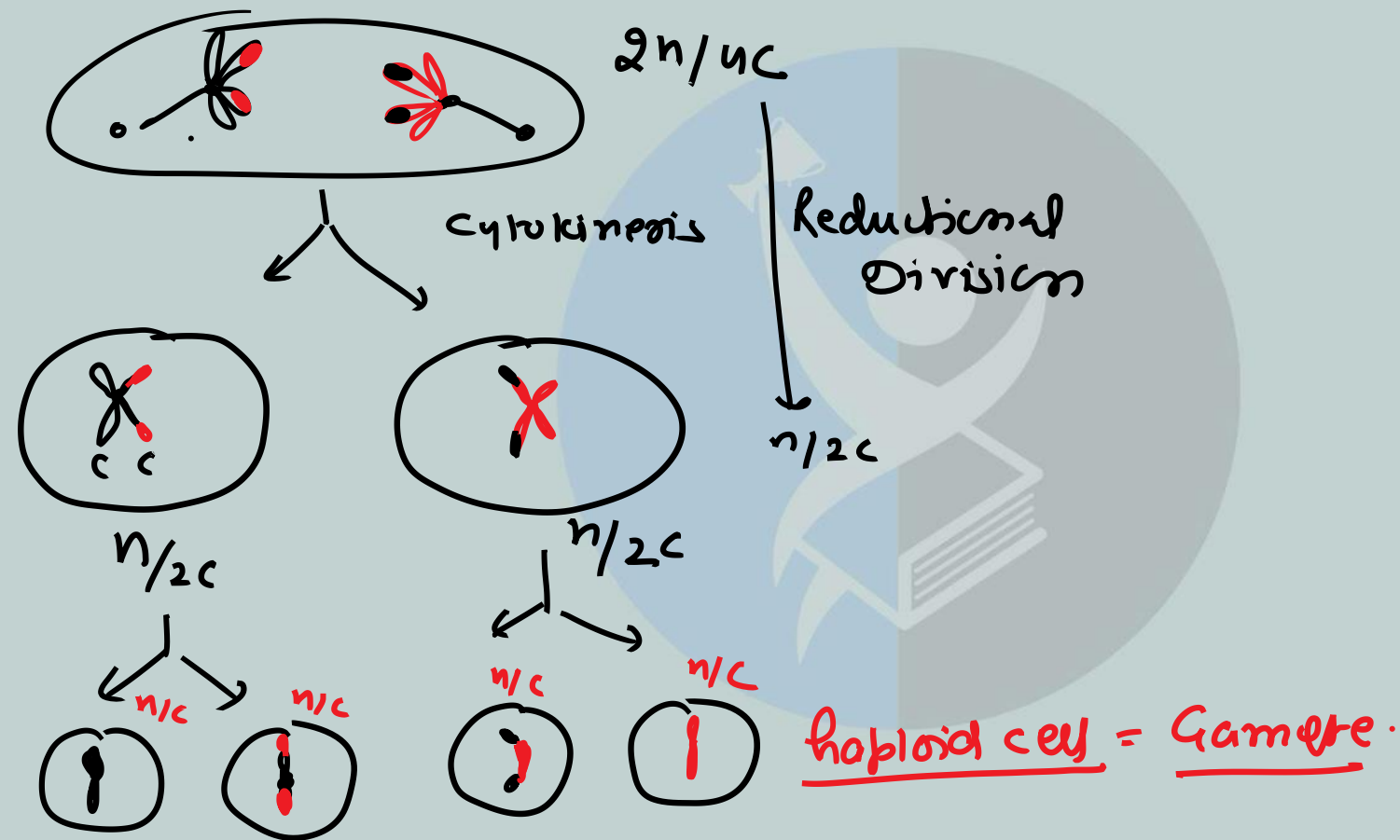
cell No $\uparrow$



Specialized For meiosis $\rightarrow$ Produce Gamete

Participate in fertilization

meiosis





- Gamete maintain Chromosome No. in

Next generation



♂

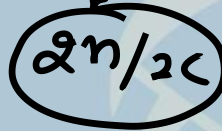
Gamete

X



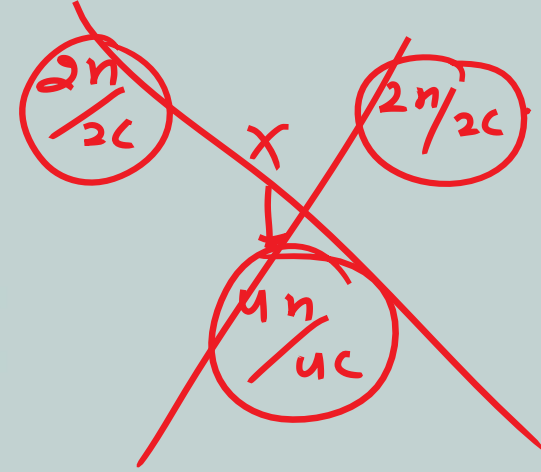
♀

Gamete



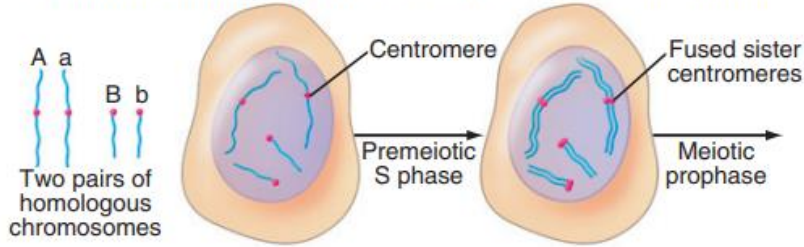
zygote

mitosis

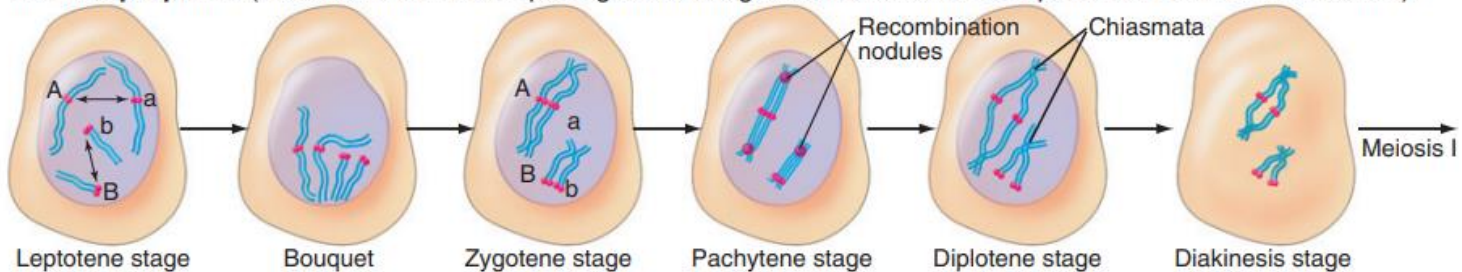


OVERVIEW OF THE PHASES OF MEIOSIS

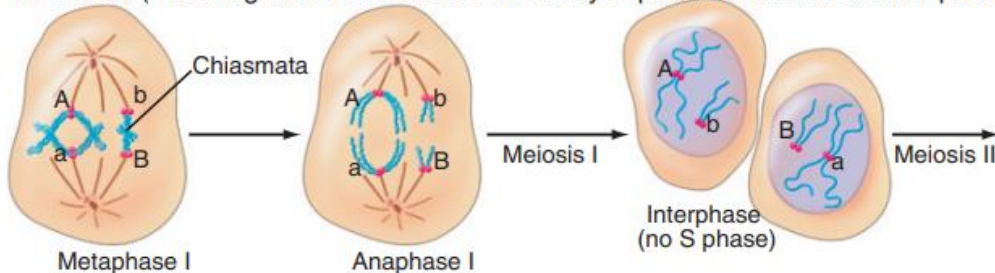
Preparation for meiosis (This step duplicates each chromatid)



Meiotic prophase (Recombination drives pairing of homologous chromosomes and produces novel chromosomes)

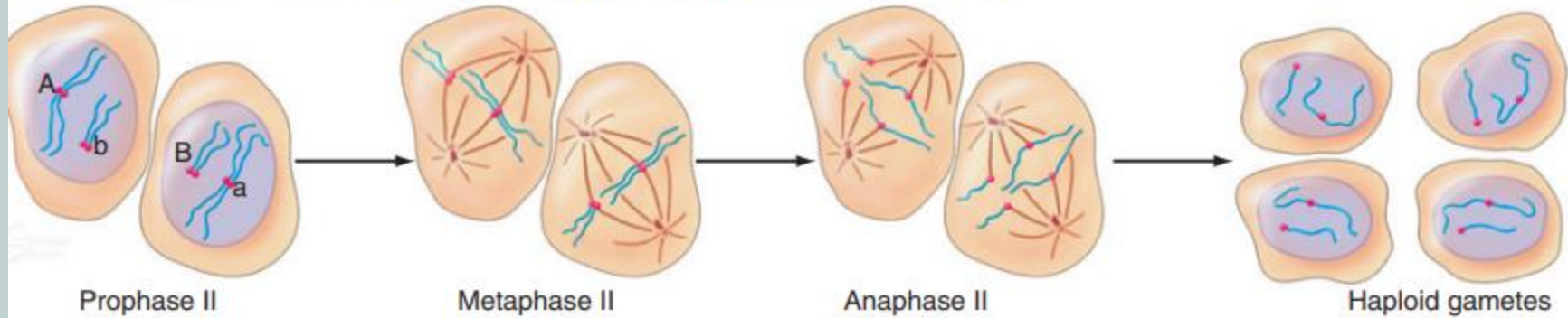


Meiosis I (Homologous chromosomes randomly separate from one another producing haploid progeny)





Meiosis II (Sister chromatids separate producing one or more gametes)



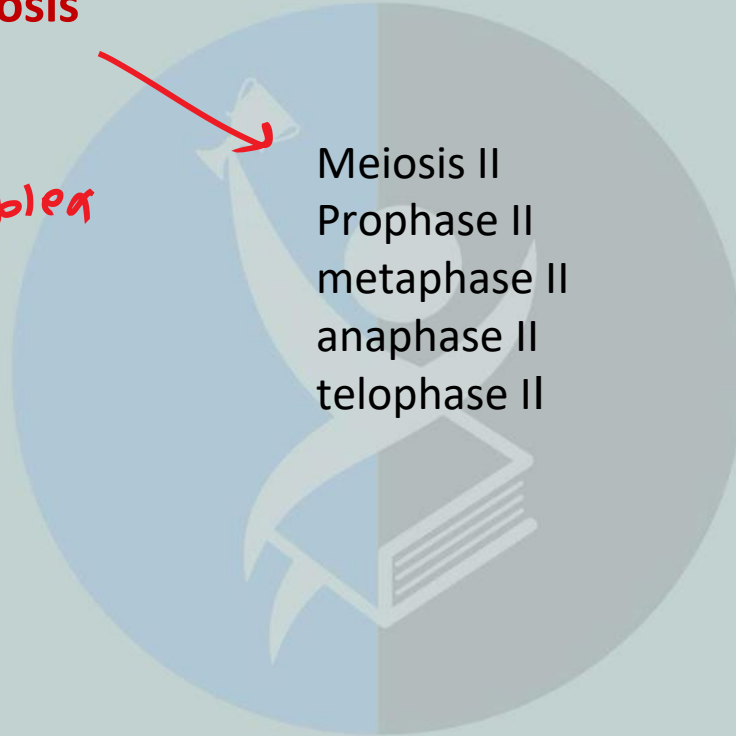


meiosis

Meiosis I

✓ Prophase I → complex
metaphase I
anaphase I
telophase I

Meiosis II
Prophase II
metaphase II
anaphase II
telophase II





Meiosis

Meiosis I

- Reductional Division

(1) prophase I longest I

- ✓ (1) leptotene,
- ✓ (2) zygotene,
- ✓ (3) pachytene,
- ✓ (4) diplotene,
- ✓ (5) diakinesis.

(2) Metaphase - I

(3) Anaphase - I

(4) Telophase I

↓
Cytokinesis

Meiosis II. = Equational Division

- Prophase II
- Metaphase II ✓
- Anaphase II
- Telophase II

↓
Cytokinesis



Stages of of Meiosis

Prophase I: The nuclear envelope disintegrates, chromosomes begin to condense and spindle fibres appear

✓ **Leptotene:** Chromatin condense and thread

✓ **Zygotene:** Pairing of homologous chromosomes (synapsis)

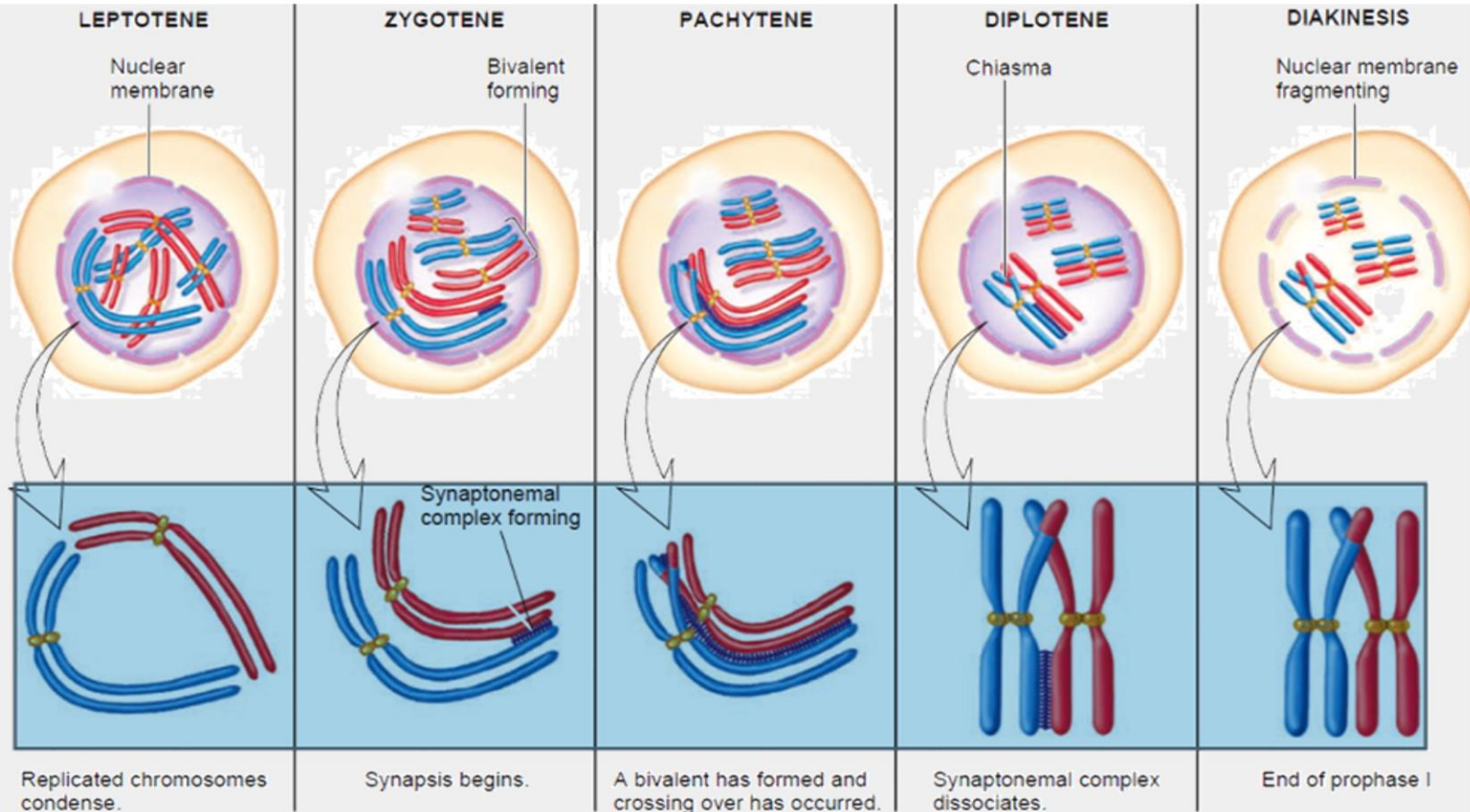
✓ **Pachytene:** Crossing over between non-sister chromatids

✓ **Diplotene:** Bivalent separate, chaisma visible

Diakinesis: Chaisma at terminus, nuclear envelope disappear

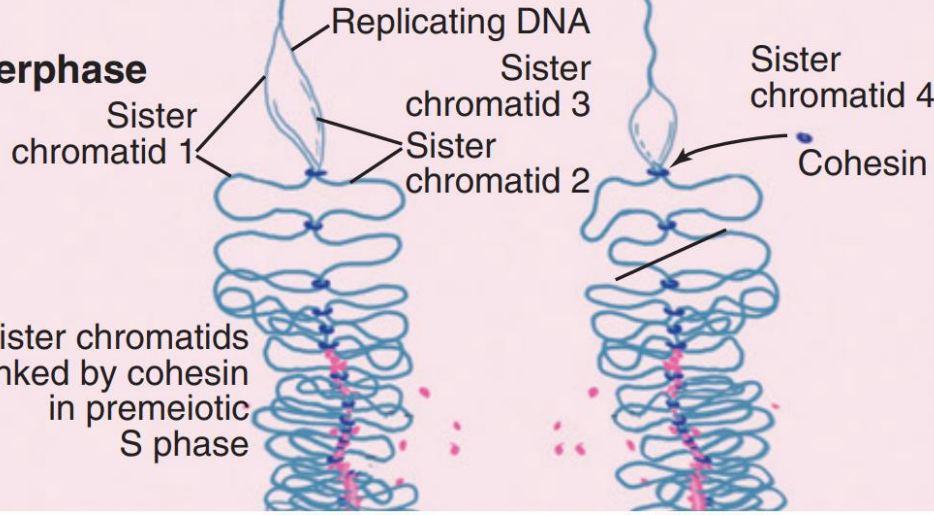


Metaphase I: The homologous chromosomes align at the equatorial plate ensuring genetic diversity among offspring.





Interphase



Leptotene

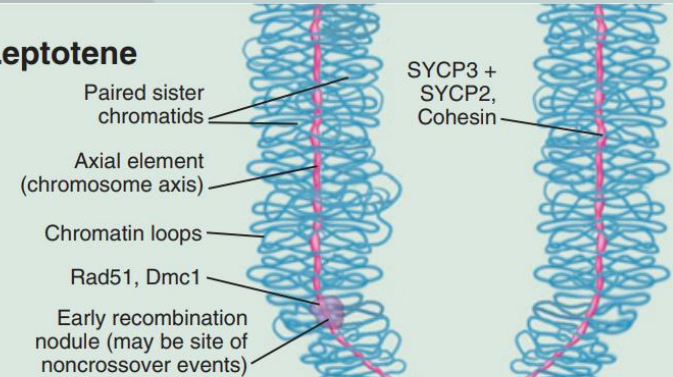


Zygotene

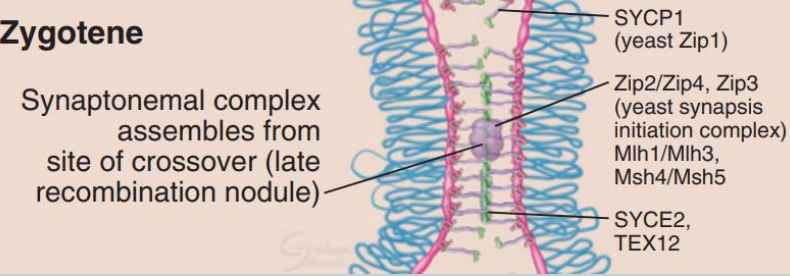


PROTEINS OF THE SYNAPTONEMAL COMPLEX

Leptotene



Zygotene





Zygotene

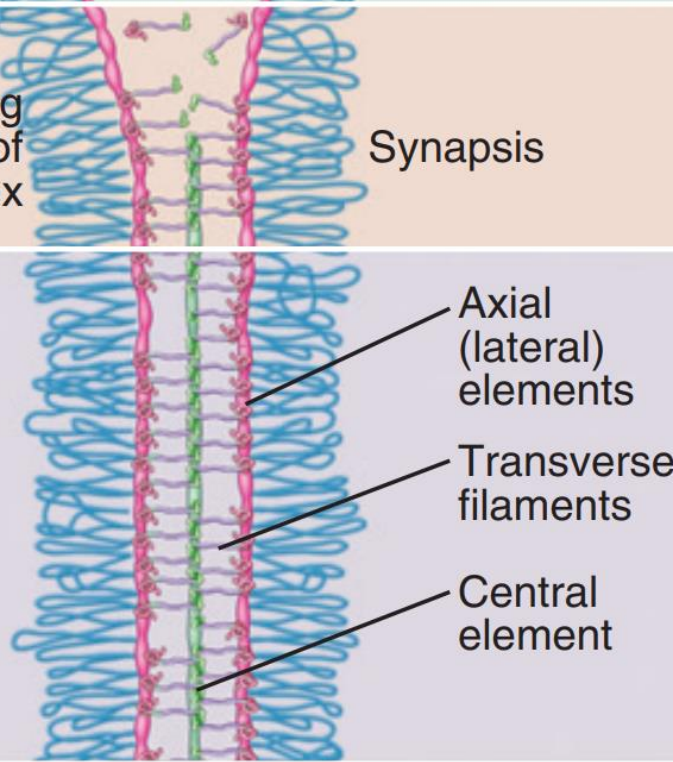
Assembling
central element of
synaptonemal complex

Synapsis

Pachytene

Recombination

• Crossing over
occurs



Synaptonemal
Complex

↓
Contains Rec 8

↓
Helps in pairing
of Homologous
Chromosome



Pachytene

Axial
(lateral)
elements

Transverse
filaments

Central
element

**Diplotene followed
by diakinesis**

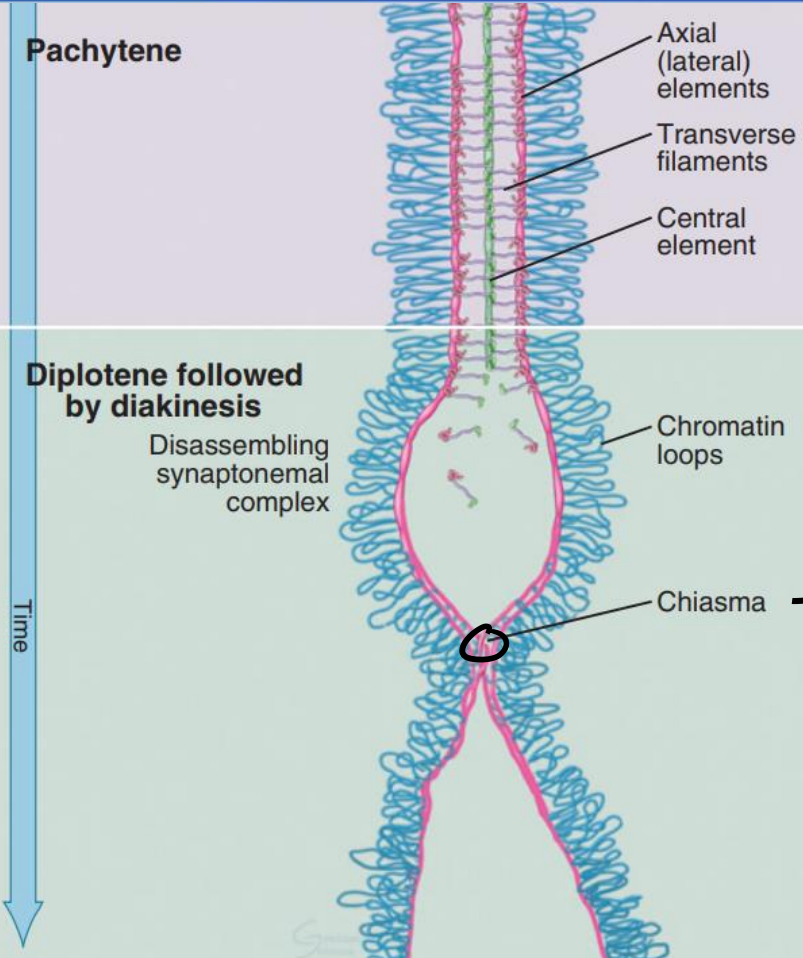
Disassembling
synaptonemal
complex

Chromatin
loops

Chiasma

→ Cross over point

Time





Anaphase I: The homologous chromosomes are pulled towards the opposite poles.



Telophase I: Spindle fibres disappear and nuclear envelope is reformed



Cytokinesis I: The cytoplasm and the cell division result in 2 non-identical haploid daughter cells.



Prophase II: The chromatin condenses into chromosomes. Nuclear envelope disintegrates. Centrosomes migrate to either poles. Spindle fibres are reformed.

m-I

m-II

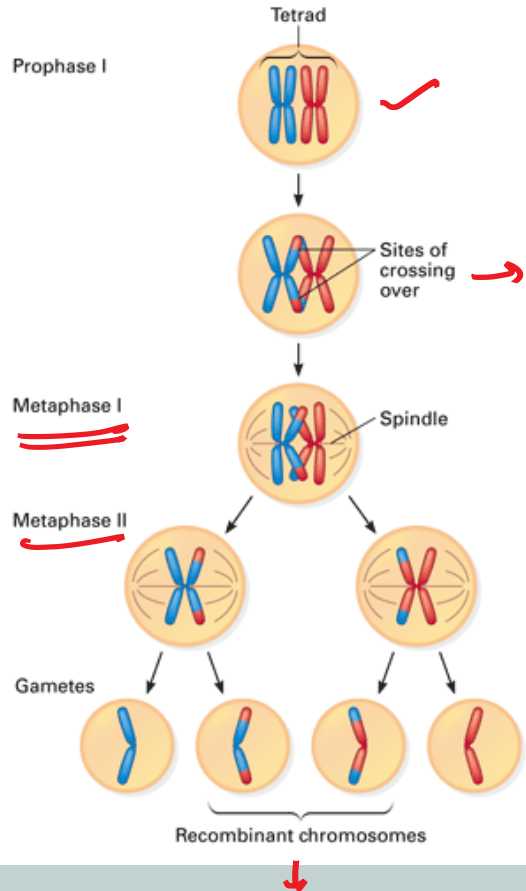


Metaphase II: The chromosomes align along the equatorial plate. On the contrary, the chromosomes in metaphase I were in homologous pairs.

Anaphase II: Sister chromatids are pulled to the opposite poles.

Telophase II: Nuclear envelope redevelops and the spindle fibres disappear.

Cytokinesis II: The cytoplasm and cell divide producing 4 non-identical haploid daughter cells.





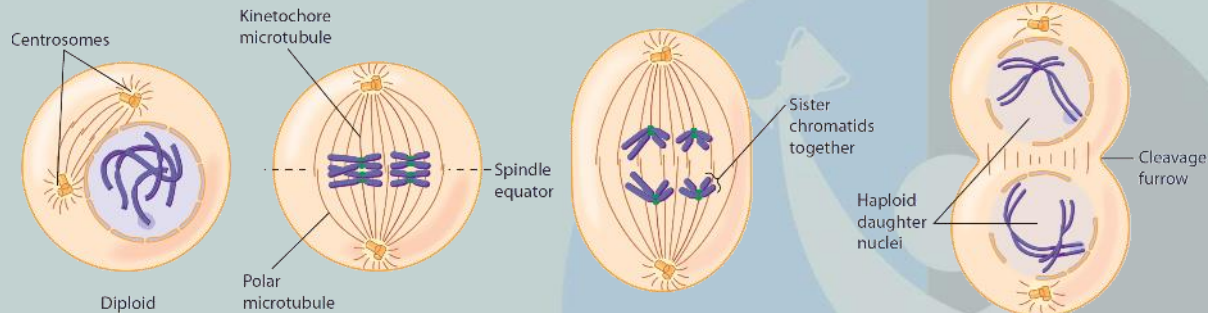
MEIOSIS I (The Reduction Division)

EARLY PROPHASE I

METAPHASE I

ANAPHASE I

TELOPHASE I AND CYTOKINESIS



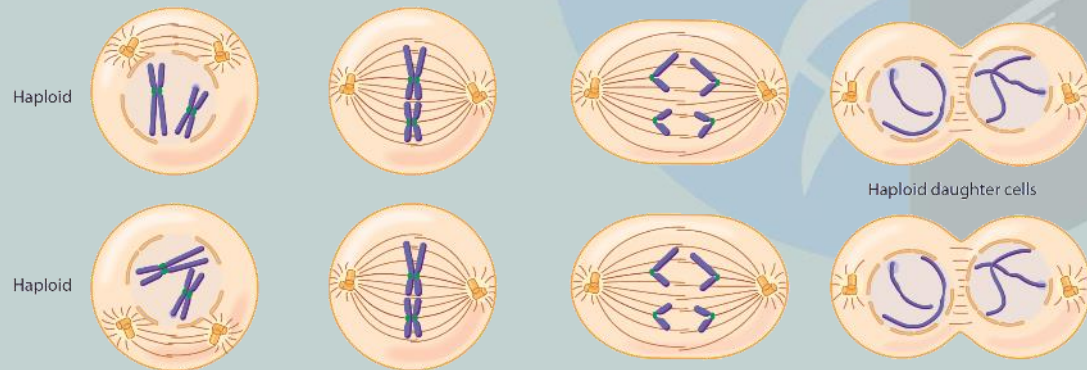
MEIOSIS II (The Separation Division)

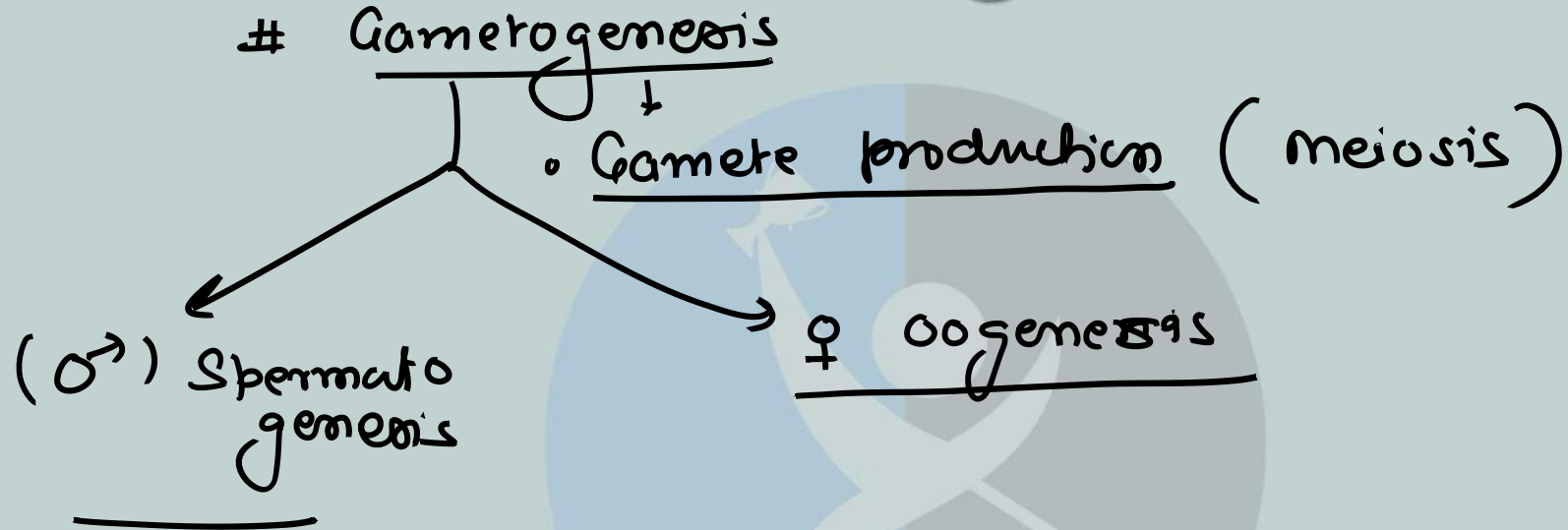
PROPHASE II

METAPHASE II

ANAPHASE II

TELOPHASE II AND CYTOKINESIS

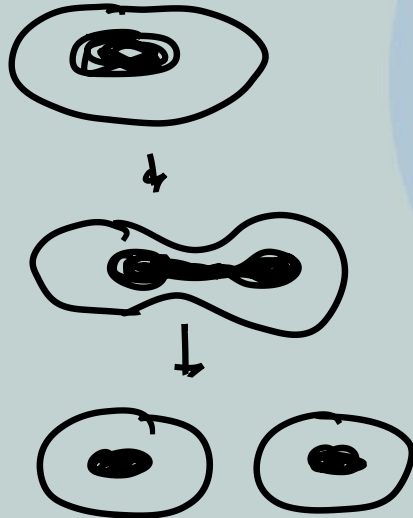




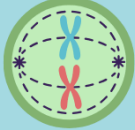
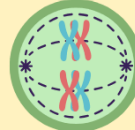
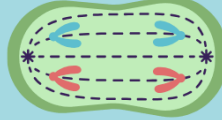
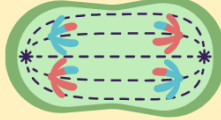
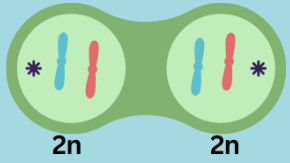
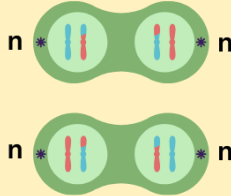


Amitosis

↳ mitosis without Chromosomal
Condensation
occurs in lower Eukaryotes



Mitosis vs Meiosis

Prophase 	Duplicated chromosomes are two sister chromatids Chromosome duplication $2n=4$	Meiosis I Prophase I  Tetrads are two pairs of sister chromatids
Metaphase 	Duplicated chromosomes align	Metaphase I  Tetrads align Crossing-over
Anaphase Telophase 	Sister chromatids separate	Anaphase I Telophase I  Homologous chromosomes separate
 $2n$ $2n$ 2 diploid daughter cells		Meiosis 2 Sister chromatids separate in anaphase II  n n n n 4 haploid daughter cells



Thank you

Learn From India's Best Educators
India's **No.1** EdTech Company for Graduates
& Post Graduates Examination.

➡ Download **IFAS** App Now



ANDROID



IOS



WINDOWS



IfAS

L1: DNA Replication

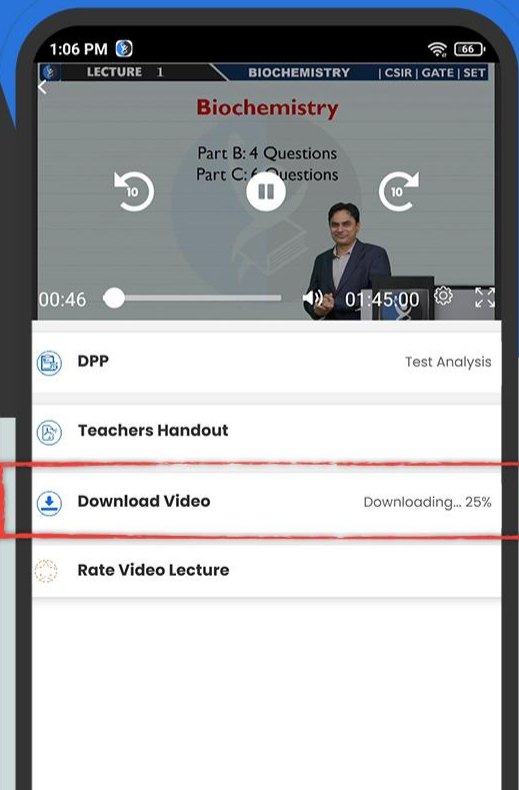


CSIR NET | GATE | SET



SAVE YOUR INTERNET DATA USAGE!

Minimize Internet Usage by Downloading Lectures from the **IfAS App** & Access them Offline





Harshada
Sharma

Earned:
₹25,500

"As is widely recognized, IFAS stands as India's leading institute for CSIR NET examination preparation. My Personal philosophy has always revolved around helping others and I've had the pleasure of introducing the IFAS Online Course to 12 of my classmates and juniors, which in turn allowed me to earn 25,500 rupees. You too can join in and refer your friends, allowing you to earn a 5% rewards based on the fees each of your referred friends Pay"



Step – 01 Invite Friends

Share your referral code or Link with your friends.

Step – 02 Earn Cashback

On Every Purchase made using your referral code, you earn 5% instant cashback in your bank account.

Step – 03 Refer More, Earn More

Keep referring as many friends as you can and keep **Earning** cash as much as you can



Friendship is Sharing, Caring, Giving & Helping Each Other...!